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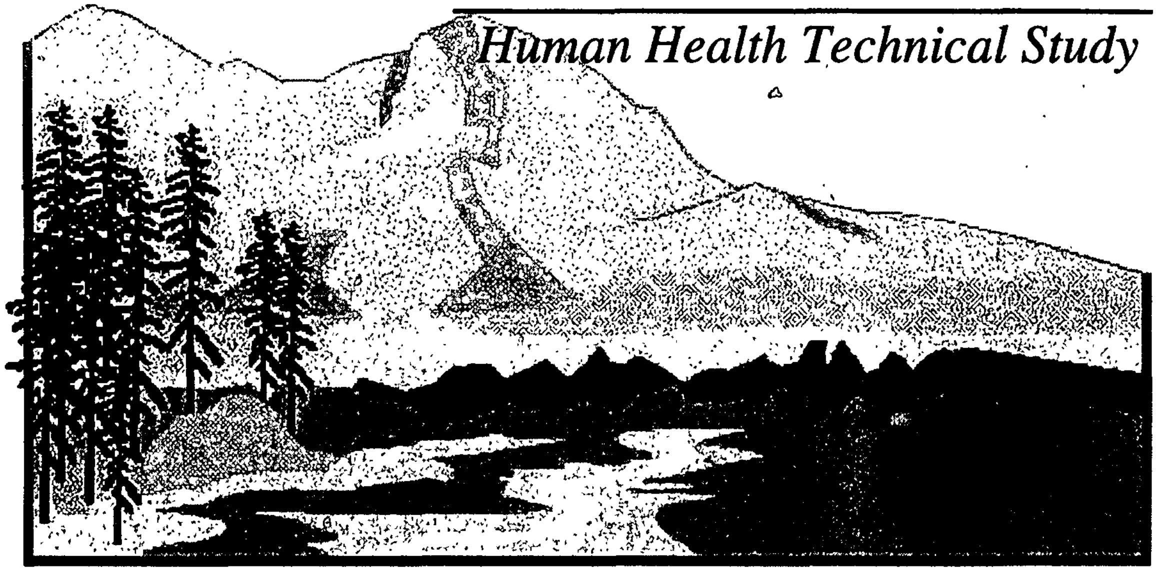
Willamette River Basin Studies:
Human Health Technical Study



HUMAN HEALTH RISK ASSESSMENT OF CHEMICAL CONTAMINANTS IN FOUR FISH SPECIES FROM THE MIDDLE WILLAMETTE RIVER, OREGON

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ARL	acceptable risk level
Axys	Axys Analytical Services
CDI	chronic daily intake
COC	chain-of-custody
COPC	chemical of potential concern
DQO	data quality objective
EVS	EVS Environment Consultants
HI	hazard index
HQ	hazard quotient
MF	modifying factor
ODEQ	Oregon Department of Environmental Quality
ODOH	Oregon Department of Health
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
QA	quality assurance
QA/QC	quality control
QAPP	quality assurance project plan
RfD	reference dose
RM	river mile
SF	cancer slope factor
TEC	toxic equivalent concentration
TEF	toxicity equivalency factor
UF	uncertainty factor
USEPA	U.S. Environmental Protection Agency

WFWF	Wheatland Ferry-Willamette Falls Reach of the Willamette River
WHO	World Health Organization
WRBTF	Willamette River Basin Task Force
WRHHS	Willamette River Human Health Subcommittee
WRTASC	Willamette River Technical Advisory Steering Committee

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EXECUTIVE SUMMARY

In 1998, the Oregon Department of Environmental Quality (ODEQ) established the Willamette River Human Health Subcommittee (WRHHS), which included representatives from ODEQ, Oregon Health Division, U.S. Environmental Protection Agency (USEPA), Oregon State University, municipal and industrial dischargers, and environmental advocate groups. This subcommittee was directed to design a study, which could be accomplished within the funding limits established by the Oregon legislature, to analyze fish from the Willamette River for chemical contaminants and assess the potential risks these chemicals pose to individuals consuming fish. Due to funding limitations, the entire Willamette River could not be evaluated. Instead, the WRHHS decided to focus on a 45-mile section of the Willamette River extending downstream from Wheatland Ferry, at River Mile (RM) 72, to the Willamette Falls near Oregon City at RM 26.5—the WFWF Reach. This section of the river was selected in part because it includes the Newberg Pool (RM 26.5-RM 52), a section of river where previous studies have found a high incidence of skeletal deformities in juvenile fish (Ellis et al. 1997; EVS 2000a). Although the cause(s) of these skeletal deformities is currently unknown, and may be unrelated to the presence of chemical contaminants in fish consumed by humans, sufficient public concern exists to warrant an assessment of the potential health risks associated with eating fish from this section of the Willamette River. This report provides a deterministic assessment of the potential health risks associated with consuming fish from the middle Willamette River.

During the first phase of this study, a qualitative fish consumption survey was conducted to identify the fish species and portions of fish being consumed by individuals catching fish from the WFWF Reach (EVS 1998a). Four fish species (smallmouth bass, common carp, northern pikeminnow, and largescale sucker) were selected to be representative of bottom fish and predatory fish being consumed by anglers. During the second phase of the study, fish were collected from the WFWF Reach on August 11–18, 1999. A total of 15 composite samples were analyzed for 85 chemicals including trace metals, polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides, polychlorinated biphenyls (PCBs), dioxins, and furans. Two types of tissue were analyzed: fillet with skin and whole-body.

Human health risks were assessed for three target populations: general public, recreational anglers, and subsistence anglers. Within each target population, risks were evaluated for adults (18 years and older), women of childbearing age (15–44 years), and children (younger than 14 years). Representative fish ingestion rates for these populations were obtained from a recent survey of per capita consumption of freshwater and estuarine fish in the United States (USEPA 2000a). Risk estimates were determined for chemicals detected in each fish species and sample type for each of the target populations. Noncancer (noncarcinogenic) health risks were assessed by calculating hazard indices

(HIs) for eleven health endpoints that describe either the mechanism or target organ that is adversely affected by chemical exposure (metabolic, hematopoietic, immunological, cardiovascular, renal, hepatic, neurological, reproductive/developmental, intestinal lesions, thyroid, and argyria). Cancer (carcinogenic) health risks were assessed by determining the probability that an individual might develop cancer over a lifetime as a result of either a 30-year or 70-year exposure to chemicals in fish. For this risk assessment, an individual lifetime excess cancer risk that exceeded 1.0E-06 or an HI of 1.0 were used as the acceptable risk levels to assess the potential for adverse health effects due to ingestion of fish containing carcinogenic and noncarcinogenic chemicals, respectively.

NONCARCINOGENIC HEALTH RISKS

General Population

HI values for all noncancer health endpoints under the general population exposure scenario were less than 1.0 for adults, women, and children. These results suggest that the exposure represented by this scenario does not pose an unacceptable noncancer health risk to the general population.

Recreational Anglers

HI values for an immunological health endpoint exceeded a value of 1.0 for adult recreational anglers for whole-body tissue samples from carp (1.8), pikeminnow (1.3), and sucker (1.4). The HI calculated for pikeminnow fillet (1.8) also exceed a value of 1.0 for a neurological health endpoint. These values may be of concern for potential health effects to immunological and neurological health endpoints. All HI values for fillet tissue from bass carp, and sucker were less than 1.0. These results suggest that the exposure represented by this scenario does not pose an unacceptable noncancer health risk to adult recreational anglers consuming only fillet tissue from bass, carp, or sucker.

HI values calculated for women of reproductive age under the recreational angler scenario were all less than 1.0. These results suggest that the exposure represented by this scenario does not pose an unacceptable risk to women of childbearing age.

Subsistence Anglers

HI values exceeded a value of 1.0 for adult subsistence anglers for several health endpoints. HI values exceeded 1.0 for all fish species and tissue types for a neurological health endpoint. HI values also exceeded 1.0 for the immunological health endpoint for all tissue types and fish species except sucker tissue. Carp whole-body tissue also had an HI exceeding 1.0 for the hepatic health endpoint. The health endpoint with the maximum HI value tended to vary by tissue type. The immunological health endpoint had the highest HI for all whole-body samples and carp fillet. The neurological health endpoints had the highest HI values for all fillet samples except carp fillet. The maximum HI values under this scenario ranged from 3.3 to 15 for fillet samples and 10 to 15 for whole-body samples. These values may be of concern for potential noncancer health effects to immunological and neurological health endpoints for adults.

Reproductive/developmental risks to women of childbearing age for the subsistence angler population scenario exceeded a value of 1.0 for all fish species and sample types. HI values for fillet tissue ranged from 2.7 to 12, while values for whole-body tissue ranged from 1.9 to 5.6. These results suggest that the exposure HI value represented by this scenario may pose an unacceptable risk to women of childbearing age.

Noncancer risk estimates for the children subsistence angler population scenario exceeded a value of 1.0 for immunological, neurological, and developmental health endpoints in all species and sample types except sucker fillet, which exceeded a value of 1.0 only for neurological and developmental health endpoints. HI values for carp fillet and carp whole body also exceeded a value of 1.0. The health endpoint with the maximum HI value tended to vary by tissue type. The immunological health endpoint had the highest HI for all whole-body samples and carp fillet. Neurological and developmental health endpoints had the highest HI values for all fillet samples except carp fillet. The maximum HI values under this scenario ranged from 4.2 to 19 for fillet samples and 13 to 19 for whole-body samples. These results suggest that the exposure represented by this scenario may pose an unacceptable noncancer health risk to children of age 14 and younger.

CARCINOGENIC RISK ESTIMATES

Total excess lifetime carcinogenic risk estimates were calculated for the three target populations for both a 30-year and 70-year exposure duration. Risk estimates for all four fish species, tissue types, and all target populations exceeded an acceptable risk level of 1.0E-06. The risk estimates for different fish and sample types for the three target populations exceed an acceptable risk level of 1.0E-06 by factors ranging from 4 to 3,000. Risk estimates for recreational anglers were higher by a factor of 2.3 than estimates for the general population. Risk estimates for subsistence anglers were higher by a factor of 19 than estimates for the general population.

Cancer risk estimates for consuming whole-body fish tissue were on average 5.2 times greater than estimates for consuming fillet tissue; risk estimates were lowest for largescale sucker and increased in ascending order for northern pikeminnow, and carp. Risk estimates for fillet tissue varied 8-fold among the four fish species. Risk estimates for fillet tissue were lowest for largescale sucker and increased in ascending order for smallmouth bass, northern pikeminnow, and carp.

CHEMICALS OF POTENTIAL CONCERN

Chemicals of potential concern (COPCs) for noncancer heath effects were identified as analytes with a hazard quotient greater than 1.0 that contributed greater than five percent of the HI for at least one noncarcinogenic health endpoint. The highest hazard indices for all fillet samples were calculated for neurological and reproductive/developmental health effects due to mercury. On February 13, 1997, the Oregon Health Division issued an advisory for the main stem of the Willamette River, which includes the study area for this risk assessment, notifying the public of elevated levels of mercury in largemouth bass, smallmouth bass, and northern pikeminnow in the Willamette River. The advisory indicated that the Oregon Health Division issues advisories when average mercury levels reach or exceed 0.35 ppm in edible tissue. Average mercury levels in fillet tissue measured in this study exceeded this threshold for smallmouth bass (0.375 ppm) and northern pikeminnow (0.717 ppm). Average mercury concentrations in carp and largescale sucker fillet tissue were below this threshold.

The highest hazard indices for whole-body fish samples were calculated for immunological health effects due to Aroclors – commercial mixtures of PCBs that have not been manufactured in the United States since 1977.

The hazard index for hepatic health effects exceeded a value of 1 (1.5) for a subsistence scenario for children consuming carp whole-body tissue. The COPCs for this health endpoint were DDE, dieldrin, and chlordane.

COPCs for cancer health effects were identified as analytes with an excess cancer risk greater than 1.0E-06 that contributed greater than five percent of the total excess cancer risk for all carcinogenic chemicals. Carcinogenic COPCs included five PCB congeners—PCB 126, PCB 118, PCB 156/157, PCB 105; two dioxins—1,2,3,7,8-PeCDD and 2,3,7,8-TCDD; three pesticides—aldrin, dieldrin, and DDE; and one metal—inorganic arsenic. The chemical contributing the greatest cancer risk in all fish species and tissue types was PCB 126.

1.0 INTRODUCTION

1.1 BACKGROUND

Protecting and improving the water quality and overall health of the Willamette River and its tributaries has been a high priority for the Oregon Department of Environmental Quality (ODEQ) for several decades. Before the implementation of wastewater treatment regulations in the 1970s, sewage and industrial discharges caused severe water quality problems in the form of low dissolved oxygen and elevated concentrations of bacteria and nutrients (Merryfield and Wilmot 1945; Merryfield et al. 1947). These problems were addressed by requiring secondary treatment of discharged wastewater, which resulted in a dramatic improvement in water quality. By the late 1980s, however, concerns about the health of the Willamette River were once again raised by reports of trace metals and organic chemicals in water and sediments and evidence of impaired biota within the Willamette River Basin (Hughes and Gannon 1987; ODEQ 1990). These reports led ODEQ to initiate further efforts to characterize and determine the causes of water quality problems.

In early 1990, the Oregon Joint Legislative Emergency Board directed ODEQ to form the Willamette River Technical Advisory Steering Committee (WRTASC). ODEQ and WRTASC conducted a comprehensive study that compiled data on environmental contaminants in the water and sediments, measured the abundance and diversity of aquatic life in the river, developed models to predict concentrations of contaminants in water and sediment, and evaluated biological indices to evaluate the health of aquatic organisms. The study was conducted during three two-year phases, culminating in 1996 with the completion of summary reports on the current status and health of the Willamette River (Tetra Tech 1995a). This study substantially advanced our understanding of the environmental problems in the Willamette River Basin. However, it did not include studies to evaluate the human health risk associated with consuming fish from the river.

In 1997, the Willamette River Basin Task Force (WRBTF) was formed and charged by Governor John Kitzhaber to assess the current status of Willamette River Basin waters, gather information on water quality problems, determine the need for further study, build consensus among the many groups whose activities affect the river, and deliver recommendations (WRBTF 1997). The task force issued a report in December 1997 identifying three human health concerns in the Willamette River Basin that should be evaluated: fish consumption, water contact recreation, and drinking water (WRBTF 1997). In response to this report, ODEQ established the Willamette River Human Health Subcommittee (WRHHS) in 1998, which included representatives from ODEQ, other state and federal agencies, universities, municipal and industrial dischargers, and environmental advocate groups. This subcommittee was directed to design a study, which could be accomplished within the funding limits established by the Oregon legislature, to address the human health concerns identified by the WRBTF.

The WRHHS recommended that a phased effort be conducted to examine the potential human health risks associated with fish consumption in the Willamette River. Funding limitations did not permit designing a comprehensive study to analyze all consumed fish species for chemical contaminants throughout the entire Willamette River. Therefore, ODEQ decided to focus on a 45-mile stretch of the river extending downstream from Wheatland Ferry, at river mile (RM) 72, to the Willamette Falls near Oregon City at RM 26.5 (the Wheatland Ferry-Willamette Falls [WFWF] Reach). This reach was chosen for study partly because it includes the Newberg Pool (RM 26.5-RM 52), a previously identified area of concern. Prior surveys conducted during 1992, 1993, 1994, and 1998 have shown that juvenile fish within the Newberg Pool have an elevated incidence of skeletal deformities (Ellis et al. 1997; EVS 2000b). Although the cause(s) of these skeletal deformities is currently unknown, and may be unrelated to the presence of chemical contaminants in fish consumed by humans, sufficient public concern exists to warrant an assessment of potential human health risks associated with eating fish from the Newberg Pool.

1.2 ENVIRONMENTAL SETTING

The Willamette River is the 13th largest river in the contiguous United States in terms of total discharge (Kammerer 1990). The headwaters of the main stem of the Willamette River originate at the confluence of the Coast Fork and the Middle Fork near Eugene, Oregon. The river flows north from Eugene approximately 187 river miles to the Columbia River near Portland, Oregon (Hines et al. 1977).

The fish evaluated in this risk assessment were collected within a 45-mile stretch of the Willamette River extending downstream from Wheatland Ferry (RM 72) to the Willamette Falls near Oregon City (RM 26.5). The largest population centers alongside, or near, this stretch of the river include the cities of Newberg, Wilsonville, Canby, and Oregon City; the 1996 Census Bureau population estimates for these cities are 17,355, 12,290, 12,465, and 22,560, respectively. Ten public boat landings and three state parks (Willamette Mission, Champoeg, and Molalla) provide recreational access to this stretch of the Willamette River (Figure 1-1). Three major municipal wastewater treatment plants, located at RM 33, RM 39, and RM 50.3, and two major industrial facilities, located at RM 27.5 and RM 50, discharge wastewater to this stretch of the Willamette River. Four major tributaries enter this stretch of the Willamette River including the Tualatin River (RM 28), Pudding and Mollalla Rivers (RM 36), and the Yamhill River (RM 55).

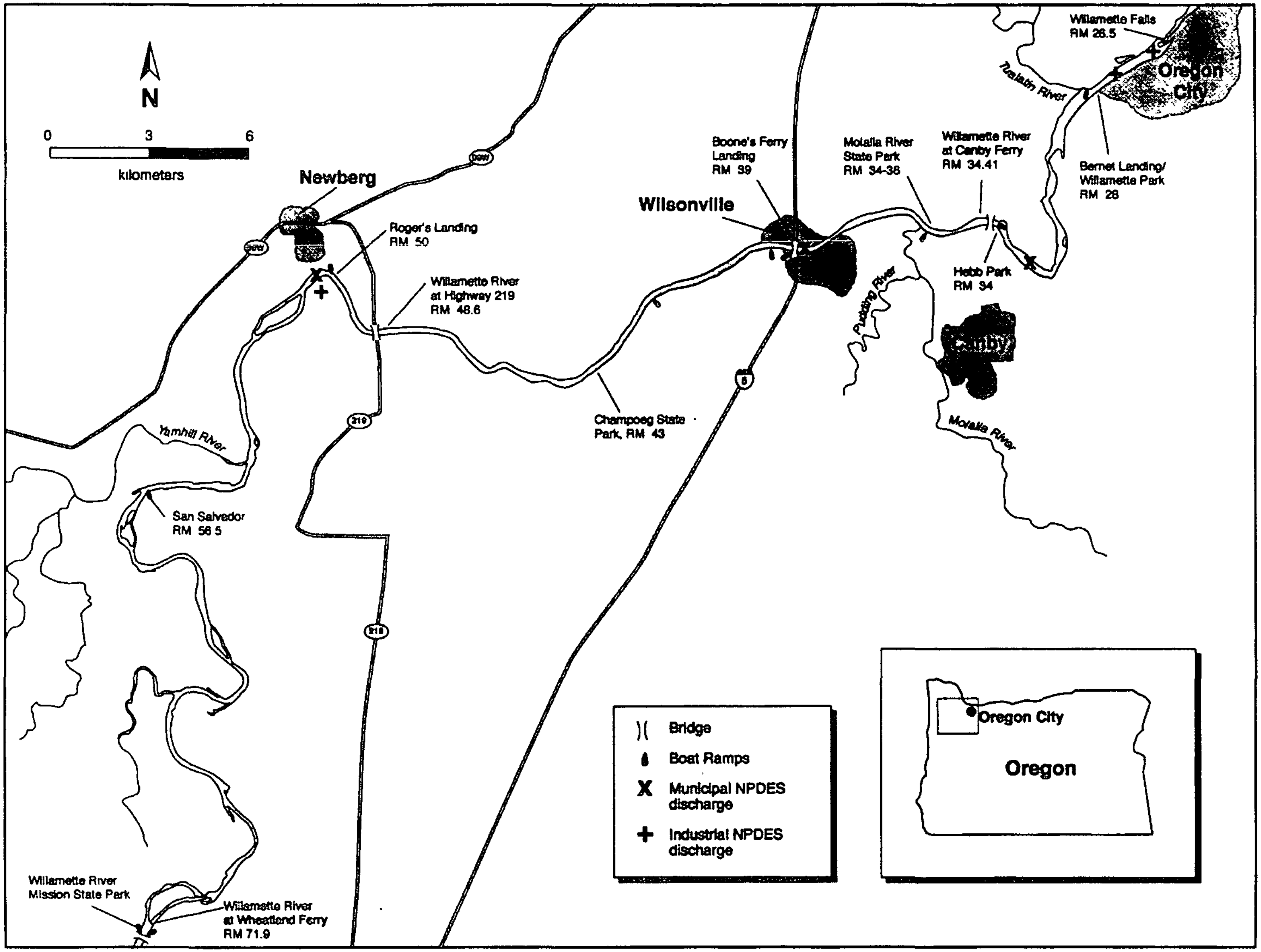


Figure 1-1. The Wheatland Ferry-Willamette Falls reach of the Willamette River

1.3 FISHERY RESOURCES IN THE WHEATLAND FERRY–WILLAMETTE FALLS REACH

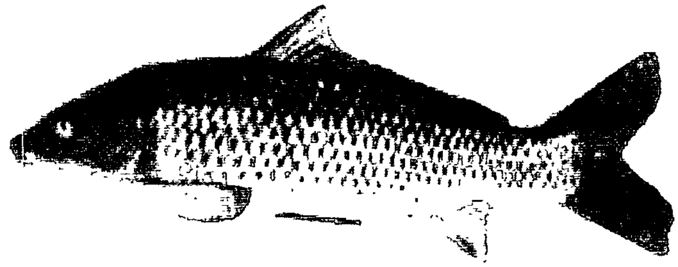
Four resident fish species were selected for analysis in this risk assessment. These species were selected following the compilation of existing information on the relative abundance of different species of fish in the WFWF Reach (Table 1-1) and the completion of a qualitative fish consumption survey to identify the Willamette River fish species being consumed by various ethnic groups along this reach of the Willamette River (EVS 1998b). The intention was to integrate these data with subsequent chemical analyses of consumed fish species to provide an estimate of the health risks associated with consuming fish. A brief description of the fish species analyzed in this study and the rationale for including them in this risk assessment are provided below. Figure 1-2 shows pictures of the four target fish species evaluated in this risk assessment.

Table 1-1. Fish abundance in the Wheatland Ferry-Willamette Falls Reach of the Willamette River from 1992 to 1994

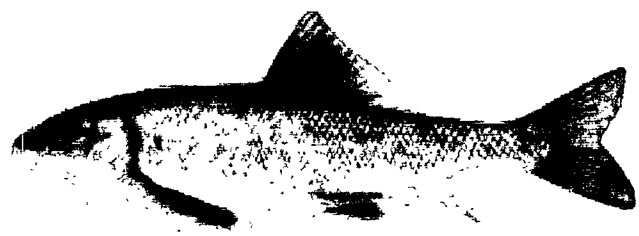
SPECIES	1992	1993	1994	TOTAL	PERCENT OF TOTAL
Northern pikeminnow	144	114	14	272	21.8
Smallmouth bass	240	9	12	261	20.9
Redside shiner	143	89	3	235	18.8
Largescale sucker	75	42	12	129	10.3
Largemouth bass	106	11	4	121	9.7
Chiselmouth	21	55	2	78	6.2
American shad	58	1	2	61	4.9
Sculpin	8	10	–	18	1.4
Bluegill	16	1	–	17	1.4
Chinook salmon	9	4	–	13	1.0
Mountain whitefish	–	9	–	9	0.7
Carp	4	4	–	8	0.6
Pumpkinseed	–	6	–	6	0.5
Dace	–	5	–	5	0.4
Mountain sucker	–	4	–	4	0.3
Peamouth	–	4	–	4	0.3
Rainbow trout	–	2	–	2	0.2
Mosquitofish	1	–	–	1	0.1
White crappie	–	1	–	1	0.1
Yellow perch	–	1	–	1	0.1
Starry flounder	–	1	–	1	0.1
Cutthroat trout	–	1	–	1	0.1
Steelhead	–	1	–	1	0.1
Black crappie	–	–	1	1	0.1
All species	825	375	50	1,250	

SOURCE: Tetra Tech (1995c)

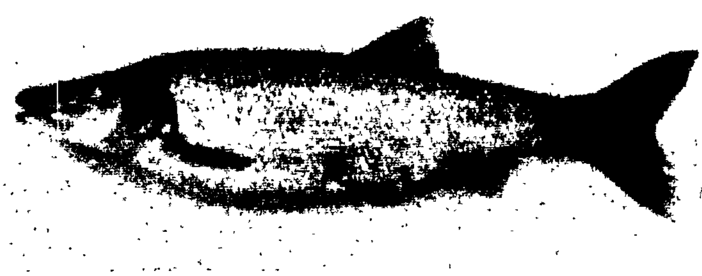
NOTE: Data collected from sites located between RM 25 and RM 57
– = not found



Carp, *Cyprinus carpio*



Largescale sucker, *Catostomus macrocheilus*



Northern pikeminnow, *Ptychocheilus oregonensis*

Smallmouth bass, *Micropterus dolomieui*

(Adapted from Wydoski and Whitney 1979, with permission)

Figure 1-2. Target fish species

Carp (***Cyprinus carpio***), a species of minnow native to Asia, was introduced to North America because of its suitability for pond culture and its use as a food fish (Scott and Crossman 1973). It is the largest minnow found in Northwestern waters and is now considered a nuisance fish in many areas because of its competition with game fish and waterfowl for forage (Wydoski and Whitney 1979). Carp are omnivorous and consume plant and animal tissue, and may selectively feed on bottom benthos and detritus. Animal prey items include aquatic insects, crustaceans, annelids, and mollusks (Scott and Crossman 1973).

Electroshocking surveys conducted during the summers of 1992, 1993, and 1994 at several sites within the WFWF Reach collected few carp (Table 1-1), which suggests that this species may not be extremely abundant within this reach of the Willamette River. However, the results of a qualitative fish consumption survey conducted in 1998 to determine what fish species were being caught in the WFWF reach showed that anglers within the Asian and Russian ethnic communities target carp for consumption (EVS 1998b). Tetra Tech (1996) evaluated the human health risks associated with consuming seven fish species (carp, largescale sucker, peamouth, white sturgeon, coho, and chinook) and crayfish from the lower Columbia River. This study reported that the risk estimates for cancer were highest for whole-body and fillet samples of carp. The information that carp within the WFWF reach are apparently being targeted for consumption, along with the suggestion that consumption of this species might pose a greater risk than other fish species, were deemed to be good reasons for evaluating the potential health risks of consuming carp from the Willamette River.

Largescale sucker (***Catostomus macrocheilus***) is a bottom fish native to the Pacific Northwest. Larger individuals feed on a variety of bottom organisms including crustaceans, aquatic insect larvae, earthworms, snails, and detritus (Wydoski and Whitney 1979).

Electroshocking surveys conducted during the summers of 1992, 1993, and 1994 at several sites within the WFWF reach found that largescale sucker, referred to hereafter as sucker, ranked fourth in abundance among the 24 fish species observed in this reach of the Willamette River (Table 1-1). None of the individuals contacted in the 1998 qualitative fish consumption survey felt that anglers preferentially target sucker for consumption (EVS 1998b). However, representatives of the Asian ethnic community did indicate that anglers tended to eat "almost anything" they catch and that sucker was likely being consumed. Tetra Tech (1996) reported that human health risk estimates for developmental, immunological, and hepatic health endpoints were highest for the consumption of whole-body samples of sucker. The relatively high abundance of sucker within the WFWF reach, along with the suggestion that consumption of this species might pose a greater risk than other fish species, were deemed to be good reasons for evaluating the potential health risks of consuming sucker from the Willamette River.

Northern pikeminnow (*Ptychocheilus oregonensis*), formerly called northern squawfish, is a fish native to the Pacific Northwest. Small pikeminnow feed primarily on insects; as the fish get larger, they feed primarily on other fish (Wydowski and Whitney 1979).

Electroshocking surveys conducted during the summers of 1992, 1993, and 1994 at several sites within the WFWF reach found that northern pikeminnow, referred to hereafter as pikeminnow, had the highest abundance of the 24 fish species observed in this reach of the Willamette River (Table 1-1). Information collected during the 1998 qualitative fish consumption survey of this reach of the Willamette River suggests that pikeminnow are consumed by some individuals within the Caucasian and Asian ethnic communities (EVS 1998b). The potential human health risk associated with consuming this species has not been evaluated in other regional risk assessments (Tetra Tech 1996). The high abundance of this species in the WFWF reach, its trophic position as a predator where it may bioaccumulate chemical contaminants of concern, and the scarcity of data on chemical concentrations in this species provided the rationale for assessing the potential health risks of consuming pikeminnow from the Willamette River.

Smallmouth bass (*Micropterus dolomieui*) is a popular game fish targeted by many anglers. Adult fish feed on insects, crayfish, and other fish (Wydoski and Whitney 1979). Electroshocking surveys conducted during the summers of 1992, 1993, and 1994 at several sites within the WFWF reach found that bass, referred to hereafter as bass, ranked second in abundance among the 24 fish species observed in this reach of the Willamette River (Table 1-1). Information collected during the 1998 qualitative fish consumption survey of this reach of the Willamette River suggests that bass are targeted by anglers within the African American, Caucasian and Asian ethnic communities (EVS 1998b). The potential human health risk associated with consuming this species has not been evaluated in other regional risk assessments (Tetra Tech 1996). The high abundance of this species in the WFWF reach, its trophic position as a predator where it may bioaccumulate chemical contaminants of concern, the scarcity of data on chemical concentrations in this species, and its popularity as a game species provided the rationale for assessing the potential health risks of consuming bass from the Willamette River.

1.4 OVERVIEW OF APPROACH

This fish consumption risk assessment follows the methodology recommended by the U.S. Environmental Protection Agency (USEPA) for the assessment of cancer and noncarcinogenic toxicity (USEPA 1997a). This methodology generally includes the following four steps:

- **Hazard identification**—identifying the chemicals of concern to be included in the risk assessment and characterizing the toxicological hazards posed by these chemicals in samples of fish.

- **Dose-response assessment**—quantitatively characterizing the relationship between the dose of a toxicant and the incidence of adverse health effects in humans.

- **Exposure assessment**—characterizing the magnitude, frequency, and duration of exposure to chemicals in fish. This assessment addresses how often individuals eat fish, how much and what portions of the fish are consumed, and for how many years fish are consumed from the study area.

- **Risk characterization**—estimating the potential for adverse health effects by integrating the information from the dose-response assessment with the exposure assessment.

The following sections provide a brief overview of the approach used to accomplish each of the four steps listed above.

1.4.1 Hazard Identification

The suite of chemicals analyzed in this risk assessment were selected by reviewing historical fish tissue chemistry data within the Willamette River basin (USEPA Region 10's Columbia River Basin Fish Contaminant database [Tetra Tech 1995b]; Willamette River Toxics Study 1988/1991 [ODEQ 1994]) and by reviewing water quality data collected by the U.S. Geological Survey on a wide range of pesticides and herbicides (Anderson et al. 1997). A total of 85 chemicals were selected for analysis.

1.4.2 Dose-Response Assessment

The quantitative relationship between the chemical dose and the incidence of adverse health effects in humans was assessed using toxicity data available in USEPA databases (USEPA 1997b; USEPA 2000a). Toxicological information for chemicals included in this risk assessment was obtained, in order of precedence, from USEPA's IRIS database (USEPA 2000a) and USEPA's Health Effects Assessment Summary Tables (HEAST) (USEPA 1997b).

1.4.3 Exposure Assessment

This risk assessment evaluated exposure to chemicals detected in fish tissue. Other possible pathways of exposure to the chemicals analyzed in this study were not evaluated. The magnitude, frequency, and duration of exposure to chemicals in fish were assessed by selecting default exposure parameters for hypothetical individuals that were assumed to represent fish consumption for the general public, recreational anglers, and subsistence anglers. Exposure for adults, women of childbearing age (15-44), and children (14 and younger) was assessed for each of the three categories of individuals, referred to as target populations. In this report, exposure to chemicals in fish tissue was assessed separately for each of the four fish species analyzed.

1.4.4 Risk Characterization

This report characterizes the potential health effects associated with consuming four fish species from the WFWF reach of the Willamette River. Two categories of health effects were evaluated: 1) the probability of an individual developing cancer over a lifetime as a result of exposure to carcinogens (carcinogenic risk); and 2) health effects other than cancer (noncarcinogenic risk). Risk estimates are presented for each of the four fish species analyzed in this study. The risk characterization also compares the relative risk of different chemicals to determine which chemicals pose the greatest risk to fish consumers.

1.5 REPORT ORGANIZATION

This report is organized into seven sections. Section 1.0 provides the background, environmental setting, and overview of the approach for the risk assessment. Section 2.0 describes the study design and the field and laboratory procedures. Section 3.0 discusses the exposure assessment. Section 4.0 describes how the toxicity of chemicals measured in fish tissue was evaluated. Section 5.0 is the risk characterization, which includes a discussion of the potential carcinogenic and noncarcinogenic risk associated with the consumption of each of the four target fish species. Section 6.0 discusses some of the major sources of uncertainty associated with this risk assessment. Section 7.0 compares fish tissue concentrations measured in this study with other data collected within the Willamette and Columbia River basins.

2.0 STUDY DESIGN AND METHODS

This section describes the study design and the field and laboratory methods used to generate the data for this risk assessment. It also includes a discussion of the quality assurance/quality control (QA/QC) results from the laboratory and an evaluation of the overall usability of the analytical data for accomplishing the objectives of this study.

2.1 STUDY DESIGN

On April 2, 1999, staff from ODEQ, the Oregon Department of Health (ODOH), and EVS Environment Consultants (EVS) met to discuss and finalize the objectives and design of the human health risk assessment of chemicals in fish tissue. The outcome of this meeting was a study design that participants felt would maximize the collection of information, within the budget allocated for this study, for assessing potential health risks associated with consuming fish from the WFWF reach. Four general objectives influenced the study design for this risk assessment:

- Tissue analysis should evaluate a comprehensive list of chemical analytes
- Fish species selected for analysis should be among the fish species likely being consumed by anglers and include species that because of their proximity to sediments, lipid content, and their trophic status, might be expected to have higher tissue concentrations of lipophilic or bioaccumulative chemicals than other fish species
- Both fillet and whole-body tissue samples should be analyzed to provide information on the relative risk associated with consuming fish parts other than the fillet
- Target species should be collected throughout the study area

2.1.1 Target Analytes

The suite of chemicals analyzed in this risk assessment were selected by conducting a risk-based screening analysis of historical fish tissue chemistry data collected within the Willamette River basin (USEPA Region 10's Columbia River Basin Fish Contaminant database [Tetra Tech 1995b]; Willamette River Toxics Study 1988/1991 [ODEQ 1994]) and by reviewing water quality data collected by the U.S. Geological Survey on a wide range of pesticides and herbicides (Anderson et al. 1997). Four general classes of chemicals were selected for analysis: trace metals, polycyclic aromatic hydrocarbons

(PAHs), organochlorine pesticides, polychlorinated biphenyls (PCBs), and dioxins/furans (Table 2-1).

2.1.2 Target Fish Species

The rationale for the selection of the four fish species analyzed in this study is discussed in Section 1.2.2. The four species represent bottom-feeding fish (carp and sucker) or predators (pikeminnow and bass) that because of their proximity to sediments, lipid content, and their trophic status, might be expected to have higher tissue concentrations of lipophilic or bioaccumulative chemicals than other fish species within the WFWF reach. Thus, while it is recognized that anglers are likely to consume fish species from the WFWF reach that were not included in this study, the four species were selected to provide information on species that might pose the greatest risk to fish consumers. ODEQ and ODOH staff involved in study design expressed the opinion that this "worst-case" assessment was an appropriate design given the limited number of samples (15) that could be analyzed in this study. This approach is consistent with USEPA's tiered guidance for assessing chemical contaminant data for use in state fish advisory programs (USEPA 1995).

2.1.3 Sample Type

A qualitative fish consumption survey was conducted in 1998 to determine what fish species and what portions of the fish are being consumed by anglers catching fish from the WFWF reach (EVS 1998b). While some respondents to this survey indicated that the fish fillet was preferentially consumed, a number of individuals stated that all parts of the fish were consumed. The study design included the analysis of two types of tissue samples (fillet with skin and whole-body) in carp, sucker, and pikeminnow to allow the evaluation of potential health risks of consuming parts of the fish other than the fillet. Fillet samples with skin were the only tissue type analyzed for bass. Whole-body samples were not analyzed for bass because fillet and skin were the only parts of this species that respondents to the 1998 qualitative consumption survey indicated were being consumed (EVS 1998b).

All samples analyzed in this study were composite samples formed by homogenizing tissue from five or eight individual fish. The use of composite samples is the most cost-effective method for estimating average tissue concentrations of analytes in target species populations to assess chronic human health risks (USEPA 1995). The number of fish per composite was selected to be consistent with other past (Tetra Tech 1996) and ongoing regional (Tetra Tech 1994; USEPA 1996b) risk assessments of fish consumption within the Columbia River basin. The study design adhered to USEPA recommendations that individual fish within the composite samples be of similar size, with the length of the smallest fish in each composite no less than 75 percent length of the largest fish (USEPA 1995).

Table 2-1. Inorganic and organic analytes measured in fish tissue

Trace Elements	PAHs	Organochlorine Pesticides	Aroclors	PCB Congeners	Dioxins and Furans
Antimony	Acenaphthene	Aldrin	Aroclor 1242	3,3',4,4'-TCB (77)	2,3,7,8-TCDD
Arsenic[a]	Acenaphthylene	cis-Chlordane	Aroclor 1254	2',3,4,4',5-PeCB (123)	1,2,3,7,8-PeCDD
Beryllium	Anthracene	trans-Chlordane	Aroclor 1260	2,3',4,4',5-PeCB (118)	1,2,3,4,7,8-HxCDD
Cadmium	Benz(a)anthracene	o,p'-DDD		2,3,4,4'5-PeCB (114)	1,2,3,6,7,8-HxCDD
Chromium	Benzo(a)pyrene	p,p'-DDD		2,3,3'4,4'-PeCB (105)	1,2,3,7,8,9-HxCDD
Copper	Benzo(e)pyrene	o,p'-DDE		3,3'4,4',5-PeCB (126)	1,2,3,4,6,7,8-HpCDD
Lead	Benzo(ghi)perylene	p,p'-DDE		2,3',4,4',5,5'-HxCB (167)	OCDD
Mercury	Benzo(bjk)fluoranthenes	o,p'-DDT		2,3,3',4,4',5-HxCB(157)[b]	2,3,7,8-TCDF
Nickel	Chrysene	p,p'-DDT		2,3,3',4,4',5'-HxCB (156)[b]	1,2,3,7,8-PeCDF
Silver	Dibenz(ah)anthracene	Dieldrin		3,3',4,4',5,5'-HxCB (169)	2,3,4,7,8-PeCDF
Thallium	Fluoranthene	alpha-Endosulfan (I)		2,2',3,4,4',5,5'-HpCB (180)[c]	1,2,3,4,7,8-HxCDF
Zinc	Fluorene	Endrin		2,3,3',4',5,5',6-HpCB (193)[c]	1,2,3,6,7,8-HxCDF
	Indeno(1,2,3-cd)pyrene	alpha HCH		2,2',3,3',4,4',5-HpCB (170)	1,2,3,7,8,9-HxCDF
	Naphthalene	beta HCH		2,3,3',4,4',5,5'-HpCB (189)	2,3,4,6,7,8-HxCDF
	Perylene	gamma HCH			1,2,3,4,6,7,8-HpCDF
	Phenanthrene	Heptachlor			1,2,3,4,7,8,9-HpCDF
	Pyrene	Heptachlor epoxide			OCDF
		Hexachlorobenzene			
		Methoxychlor			
		Mirex			
		cis-Nonachlor			
		trans-Nonachlor			
		Oxychlordane			

[a] Includes arsenic speciation.
[b] Congeners coeluted.
[c] Congeners coeluted.

2.1.4 Study Area

The study area for this risk assessment is a 45-mile stretch of the river extending downstream from Wheatland Ferry, at river mile (RM) 72, to the Willamette Falls near Oregon City at RM 26.5 (the WFWF Reach). This reach of the Willamette River was divided into five segments of approximately equal river mile lengths for sample collection to ensure that target fish species were collected throughout the study area (Figure 2-1). The study was designed to capture spatial variability along the river by assembling composites from each river segment. However, if target species could not be collected within a given segment, fish from other segments could be used.

2.2 FIELD ACTIVITIES

Fish were collected during August 11-18, 1999, from the five sampling segments within the WFWF reach (Table 2-2), using a boat-mounted electrofishing unit (Model 7.5 GPP, Smith-Root, Vancouver, WA) that generates approximately 3 amps direct current pulsed at 120 cycles per second. Stunned fish were identified by EVS scientists, and dip nets were used to transfer target species to plastic containers filled with river water. After a maximum interval of 60 minutes, a blow to the head with a wooden club sacrificed captured fish. Each individual fish was measured for total length and weight, double-wrapped in heavy-duty aluminum foil, and placed in a sealed plastic bag with a waterproof tag stating the species name, collection date, collection location, length, and weight. Each specimen was then immediately placed on dry ice in a cooler.

Coolers were shipped at the end of each day's collection activities for next-day delivery to Axys Analytical Services (Axys) located in Sidney, British Columbia. Chain-of-custody (COC) forms were filled out for each shipment of fish. The COC form identified the project number, sampling crew, sample identification number, date and time of collection, matrix, required analyses, and initials of the individual processing the sample. COC forms were completed in triplicate; one copy was retained prior to shipment. The COC forms were signed by Axys staff upon delivery of the coolers. The contents were inspected to ensure that the samples had arrived frozen and in good condition and then the fish were stored at –20°C prior to sample processing.

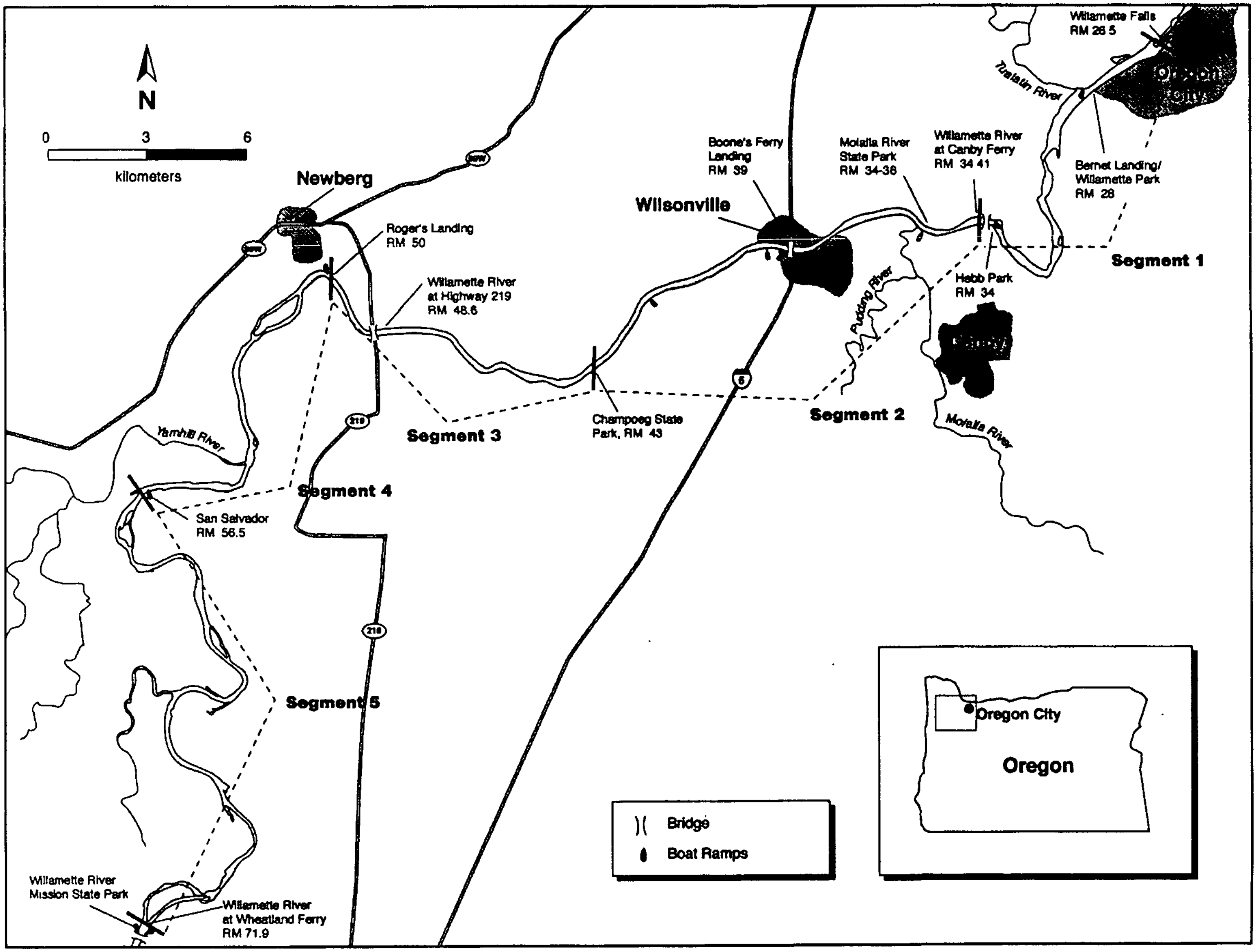


Figure 2-1. Field sampling segments within the Wheatland Ferry-Willamette Falls Reach of the Willamette River

Table 2-2. Sampling segments along the Wheatland Ferry-Willamette Falls Reach

SEGMENT	RIVER MILE	GPS COORDINATES	VISUAL LANDMARKS
1	26.5–34.4	45°21.148, 122°37.285-45°17.968, 122°41.258	Willamette Falls to Canby Ferry
2	34.4–43	45°17.968, 122°41.258-45°15.288, 122°53.040	Canby Ferry to Champoeg State Park
3	43–50	45°15.288, 122°53.040-45°17.160, 122°57.965	Champoeg State Park to Roger's Landing
4	50–56.5	45°17.160, 122°57.965-45°13.876, 122°59.758[a]	Roger's Landing to San Salvador
5	56.5–71.9	45°13.876, 122°59.758[a]-45°05.573, 122°02.483	San Salvador to Wheatland Ferry

[a] Due to dredging activities in the river channel upstream of the Yamhill River tributary, San Salvador was not accessible during field collection activities. Segment 4 collections terminated at the Yamhill River. GPS coordinates refer to the mouth of the Yamhill River and not San Salvador.

2.3 LABORATORY PROCEDURES

2.3.1 Sample Processing and Distribution

Sample processing and distribution was conducted by Axys. Coolers containing the Willamette River fish samples were received from August 13 through August 18, 1999. All samples were received frozen and in good condition. Samples were stored in freezers at –20°C until all details on sample preparation and subsequent analysis were approved by ODEQ and EVS. Sample processing commenced on September 8, 1999 and was concluded on September 15, 1999. A total of 25 carp, 10 bass, 24 pikeminnow, and 16 suckers were processed for analysis.

Composite samples were composed of tissue from either eight or five individual fish of similar total length. Tissue from eight individual fish was used to form composite samples of sucker and pikeminnow. Due to difficulties in collecting sufficient numbers of carp and bass, composite samples of these species contained tissue from five individuals. Five composite samples of fillet tissue were analyzed: one sample each from carp, sucker, and pikeminnow, and two composite samples of bass (Table 2-3). Seven composite samples of whole-body fish were analyzed: four samples from carp, two samples from pikeminnow, and one composite sample from sucker (Table 2-3). Three composite samples consisting of the tissue remaining after the fillets were removed from both sides of the fish (offal) were also analyzed: one composite sample each of carp, sucker, and pikeminnow (Table 2-3). The analytical results for the three paired composites, which contained fillet and offal tissue from the same fish (composite pairs

1,2; 8,9; and 10,11), were combined as a weighted average using measurements of the sample wet weights to calculate a whole-body concentration from the fillet and offal data. Table 2-3 shows the composite samples analyzed for this study. With one exception, all the fish used to form a composite sample were collected within a single sampling segment. Because of difficulties in collecting bass, one of the two composite samples was formed from fish collected in three river segments (Table 2-3).

Table 2-3. Final study design of the 15 composite samples analyzed for tissue concentrations

Composite No.	Species	Sample Type	No. Fish per Composite	Region Collected
1	Sucker	F	8	1
2	Sucker	WB - F	8	1
3	Carp	WB	5	2
4	Carp	WB	5	2
5	Carp	WB	5	2
6	Bass	F	5	2
7	Bass	F	5	1,3,5
8	Carp	F	5	3
9	Carp	WB - F	5	3
10	Pikeminnow	F	8	3
11	Pikeminnow	WB - F	8	3
12	Sucker	WB	8	4
13	Pikeminnow	WB	8	4
14	Carp	WB	5	5
15	Pikeminnow	WB	8	5

NOTE: WB = whole body
F = fillet with skin
WB - fillet = portion of fish remaining after removing fillets from both sides of the fish

Appendix A provides the weight and lengths of all individual fish used to form the composite samples analyzed in this study. Table 2-4 shows the average size and size range of the fish forming each composite sample.

Table 2-4. Summary of fork length (mm) and field weight (g) measurements of 15 composite samples

				Fork Length (mm)				Field Weight (g)					
Species	Sample Type	Sample ID	Number of Fish per Composite	Mean	Standard Dev	Minimum	Maximum	Mean	Standard Dev	Minimum	Maximum	Collection Segment	Percent Lipid
Bass	F	6	5	230	76	160*	320	290	214	91	544	2	1.4
Bass	F	7	5	240	61	160*	320	227	124	91	408	1,3,5	1.3
Carp	WB	3	5	531	29	490	570	2,930	526	2,495	3,719	2	7.2
Carp	WB	4	5	599	16	575	615	4,554	891	3,765	5,670	2	5.1
Carp	WB	5	5	658	35	625	715	5,271	1,466	3,266	6,713	2	8.5
Carp	F	8	5	557	16	540	570	3,629	594	2,722	4,309	3	3.5
Carp	WB - F	9	5	557	16	540	570	3,629	594	2,722	4,309	3	7.6
Carp	WB	14	5	553	58	455	600	3,320	1,077	1,724	4,309	5	6.1
Pikeminnow	F	10	8	316	34	260*	360	391	135	227	590	3	1.8
Pikeminnow	WB - F	11	8	316	34	260*	360	391	135	227	590	3	8.1
Pikeminnow	WB	13	8	304	25	275	335	318	133	181	544	4	5.8
Pikeminnow	WB	15	8	189	6	180	200	79	32	45	136	5	3.6
Sucker	F	1	8	380	7	370	390	624	67	544	726	1	2.0
Sucker	WB - F	2	8	380	7	370	390	624	67	544	726	1	9.9
Sucker	WB	12	8	369	26	330	400	601	153	318	771	4	7.9

NOTE: WB = whole body
F = fillet with skin
WB - fillet = portion of fish remaining after removing fillets from both sides of the fish

* Minimum length is less than 75 percent of the maximum length.

All processing of fish samples was conducted in a clean room at Axys. Fish fillets with skin were removed using procedures recommended by USEPA (1995) (Figure 2-2). Fish were partially thawed, scaled, and the fillet including the belly flap tissue was removed using stainless steel utensils. The fillets from both sides of individual fish were used to create composite fillet samples.

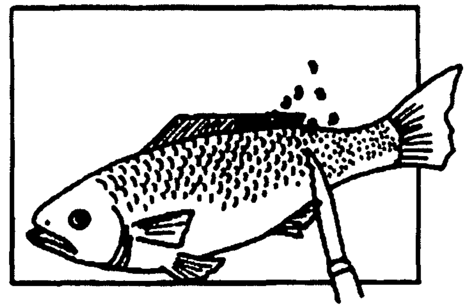
Composite samples of fillet, whole body, or offal tissue were created by homogenizing the tissue using the procedures recommended by USEPA (1995). Three types of blenders were available for use in homogenization—a Virtis mixer, Oster blender, and commercial meat grinder. The type of blender used depended upon the amount and type of tissue in the sample. Samples were hand-mixed between each pass through the blender. Homogenization equipment was cleaned thoroughly after each composite sample was prepared. Equipment was cleaned with soap and water, then rinsed with acetone, hexane, and dichloromethane, a 5 percent nitric acid solution, and lastly with deionized water.

Each homogenized composite was split and a frozen aliquot was sent for overnight delivery to Frontier Geosciences Inc. in Seattle, Washington for analysis of 11 metals. All homogenates were stored in the dark at <–10°C prior to sample extraction and analysis.

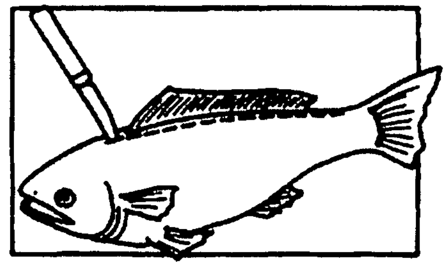
2.3.2 Analytical Methods

Tissue samples were analyzed for the target analytes listed in Table 2-1. The analytical methods used for the analysis of samples are listed in Table 2-5.

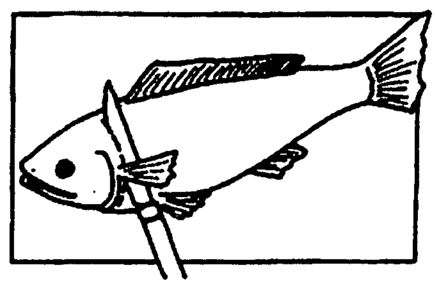
Step 1 Scales were removed by scraping with the edge of a stainless steel knife. After scaling, the fish was rinsed with deionized water.



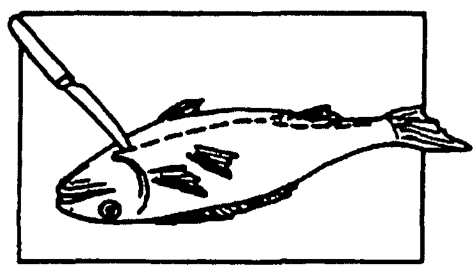
Step 2 A shallow cut was made through the skin (on either side of the dorsal fin) from the top of the head to the base of the tail.



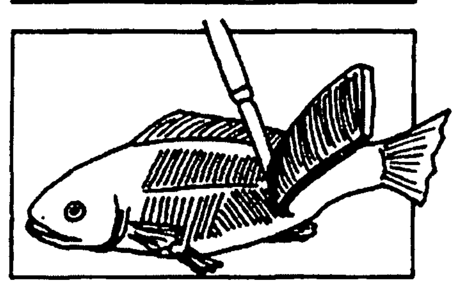
Step 3 A cut was made behind the entire length of the gill cover, cutting through the skin and flesh to the bone.



Step 4 A shallow cut was made along the belly from the base of the pectoral fin to the tail. A single cut was made from behind the gill cover to the anus and then a cut was made on both sides of the anal fin. This process did not cut into the gut cavity to avoid contaminating fillet tissue.



Step 5 The fillet was removed.



Modified from. U S. EPA, 1995

Figure 2-2. Illustration of the filleting procedures followed in this study

Table 2-5. Chemical analysis methods used for the Willamette River Basin Study

Analyte	Method
Metals:	
Total mercury	USEPA Method 1631 modified
Antimony	USEPA Method 1638/200.8 modified
Arsenic	USEPA Method 1638/200.8 modified
Beryllium	USEPA Method 1638/200.8 modified
Cadmium	USEPA Method 1638/200.8 modified
Chromium	USEPA Method 1638/200.8 modified
Copper	USEPA Method 1638/200.8 modified
Lead	USEPA Method 1638/200.8 modified
Nickel	USEPA Method 1638/200.8 modified
Silver	USEPA Method 1638/200.8 modified
Thallium	USEPA Method 1638/200.8 modified
Zinc	USEPA Method 1638/200.8 modified
Arsenic - inorganic	USEPA Method 1632 modified
Polycyclic aromatic hydrocarbons	Axys Method PH-01, Version 2 (1997)
Organochlorine pesticides	Axys Method CL-T-03, Version 2 (1997)
Polychlorinated biphenyls	Axys Method CL-T-03, Version 2 (1997) (Aroclors) USEPA Method 1668 (congeners)
Dioxins/furans	USEPA Method 1613, Revision B

2.3.3 Quality Assurance and Quality Control Considerations

Project data quality objectives were established in the Quality Assurance Project Plan (QAPP) (EVS 1999). The overall quality assurance objective for this project was to collect analytical data of known and acceptable quality so that potential health risk to fish consumers could be estimated. Data quality objectives (DQOs) were established for holding times, accuracy, precision, detection limits, and completeness to ensure that the data of acceptable quality were obtained in this project.

For the measurement of data quality objectives with a numeric objective, including precision, accuracy, and completeness, the following criteria were used:

Precision

Precision was evaluated by reviewing results from duplicate sample aliquots for metals, PAHs, pesticides, and Aroclors. Laboratory duplicates were not analyzed for dioxins, furans, and PCB congeners due to the high cost of these analyses and the desire to maximize the number of composite samples that could be analyzed.

Accuracy

- For metals, accuracy was evaluated by determining percent recoveries for three standard reference materials, dogfish muscle tissue, dogfish liver tissue, and a freshwater sample, analyzed along with the study composite samples.
- For PAHs, accuracy was evaluated by spiking each sample with nine deuterium-labeled PAHs and determining their percent recovery.
- For pesticides and Aroclors, accuracy was evaluated by spiking each sample with eight labeled surrogate standards and determining their percent recovery.
- For dioxins, furans, and PCB congeners, accuracy was evaluated by measuring labeled compound spikes of all target compounds in each sample.

Completeness

- Completeness was evaluated by determining whether the number of valid samples analyzed relative to the number of samples collected was at least 90 percent.

The chemistry data collected in this study is presented in Appendix B. The data quality assurance review is presented in Appendix C.

2.4 RELIABILITY OF DATA FOR RISK ASSESSMENT

Several factors affect the usability of environmental data for risk assessments, including the data quality criteria goals, the documentation of study activities, the analytical methods used, the detection limits achieved, and the level of QA data review (USEPA 1990).

The data quality assurance review for this study is presented in Appendix C. With the exception of two analyses for naphthalene, which could not be quantified, none of the data collected has been qualified as being unusable for the human health risk assessment. Twenty-one percent of the data collected in this study have been qualified as estimates (Table 2-6). Estimated data were considered usable for risk assessment purposes, although the uncertainty associated with risk estimates made from estimated day might be greater than assessments made from unqualified data. Nine percent of the sample analyses had concentrations reported as not detected and achieved detection limits that were higher than the study DQOs (Table 2-6). Both of these data QA issues mainly affected the analyses for PAHs, where matrix interferences resulted in low percent recoveries for analyses.

Table 2-6. Amount of study data that were qualified as estimates or exceeded detection limit data quality objectives

Chemical Group	Total No. of Analyses	No. of Sample Results Qualified as Estimates (J)	Percent of Data Qualified as Estimates (J)	No. of Not Detected Analyses where DL > DQO
Metals	234	0	0	0
PAHs	306	207	68	114
Pesticides	391	73	19	14
PCB Congeners	180	12	7	1
Aroclors	51	13	25	4
Dioxins/Furans	306	0	0	0
Total	**1,468**	**305**	**21**	**133**

NOTE: DL = detection limit
DQO = data quality objective

The default values used for the parameters in Equation 1 for the three general target populations evaluated in this risk assessment are shown in Table 3-2. A discussion of these parameters and the rationale for selecting the default values used to estimate risk is provided below.

Table 3-2. Default values used for exposure parameters to calculate chronic daily intake for target populations

		Target Population		
	Abbreviation	General Public	Recreational Angler	Subsistence Angler
Tissue Concentration	C	Average	Average	Average
Ingestion Rate (g/day)	IR			
Adults		7.5[a]	17.5[b]	142.4[c]
Women (15-44)		5.81[a]	7.86[b]	109.72[c]
Children (<14)		2.83[a]	0[b]	77.95[c]
Exposure Frequency (days/year)	EF	365	365	365
Exposure Duration (years)	ED			
Adults		30[d]/70[e]	30[d]/70[e]	30[d]/70[e]
Women (15-44)		30	30	30
Children (<14)		15	15	15
Body Weight (kg)	BW			
Adults		70[f]	70[f]	70[f]
Women (15-44)		67[g]	67[g]	67[g]
Children (<14)		30[h]	30[h]	30[h]
Averaging Time (days)	AT			
Carcinogens		25,550	25,550	25,550
Noncarcinogens		(ED x EF)	(ED x EF)	(ED x EF)

[a] Mean U.S. per capita consumption rate of uncooked freshwater and estuarine fish (USEPA 2000a).
[b] 90th percentile U.S. per capita consumption rate of uncooked freshwater and estuarine fish (USEPA 2000a).
[c] 99th percentile U.S. per capita consumption rate of uncooked freshwater and estuarine fish (USEPA 2000a).
[d] 90th percentile length of time an individual stays at one residence (USEPA 1997c).
[e] Average life expectancy of the genral public (USEPA 1989).
[f] Average body weight for adults of both sexes in the general public (USEPA 1989).
[g] Average body weight for females age 15 through 44 in the general public (USEPA 1997d).
[h] Average body weight for children of both sexes of age 6 months to 15 years in the general public (USEPA 1997d).

3.2 EXPOSURE PATHWAY

An exposure pathway describes the course a chemical or physical agent takes from the source to the exposed individual. A complete description of an exposure pathway involves four elements: 1) a source and mechanism of chemical release, 2) a retention or transport medium, 3) a point of potential human contact with the chemical (referred to as the exposure point), and 4) an exposure route, such as ingestion, at the point of contact (USEPA 1989). While several different exposure pathways could conceivably result in human exposure to chemical contaminants in the WFWF reach of the Willamette River, this risk assessment evaluates only the potential risk associated with the consumption of four species of fish from a 30-mile stretch of the Willamette River. The sources of chemicals analyzed in this study, the mechanisms by which the chemicals are mobilized in the environment, and the processes by which the chemicals accumulate in fish tissue were not evaluated.

3.3 QUANTIFICATION OF EXPOSURE

The magnitude, frequency, and duration of exposure for the exposed population must be quantified to allow an assessment of potential risk. The exposure evaluated in this risk assessment is the human ingestion of chemicals present in fish tissue. Because this exposure occurs over time, the total exposure is divided by a time period of interest to obtain an average exposure rate per unit time. When this average rate is expressed as a function of body weight, the resulting exposure rate is referred to as the chronic daily intake (CDI). The CDI of chemicals present in fish tissue was calculated using the following equation:

$$\mathrm{CDI} = \frac{\mathrm{C} \times \mathrm{CF} \times \mathrm{IR} \times \mathrm{EF} \times \mathrm{ED}}{\mathrm{BW} \times \mathrm{AT}} \qquad \text{(Equation 1)}$$

where:

CDI	=	Chronic daily intake of a specific chemical (mg/kg-day)
C	=	Chemical concentration (mg/kg)
CF	=	Conversion factor (kg/g)
IR	=	Ingestion (consumption) rate (g/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time for exposure duration (EF × ED for noncarcinogens and 70 years × 365 days/year for carcinogens)

The Aroclor concentration used to calculate carcinogenic risk will be referred to as adjusted Aroclors. This method has been suggested by the EPA as an approach to improve risk estimates based on available data (USEPA 1996a). A discussion of the quantitative comparison between adjusting Aroclors to represent only non-dioxin-like congeners compared to treating Aroclors as total PCBs is discussed in Section 6.0.

Fish Ingestion Rate

A quantitative fish consumption survey has not been conducted for the WFWF reach of the Willamette River, thus there is considerable uncertainty involving the selection of fish ingestion rates that should be used to estimate human health risk. EVS (1998b) reviewed the three existing studies that provide information on fish consumption within the Willamette River Basin (Adolfson Associates 1996; CRITFC 1994; The Research Group 1991) and concluded that the existing information demonstrates that little is known about fish consumption in the WFWF reach of the Willamette River. In the absence of site-specific information on fish consumption, recent data on per capita fish consumption of freshwater/estuarine fish in the United States was used to select default values for the ingestion of all fish species. These statistics are based on data collected by the U.S. Department of Agriculture's 1994–96 survey of food intake by individuals in all 50 states and the District of Columbia (USEPA 2000a). The fish ingestion rates used as general public default values for adults (7.5 g/day), women of childbearing age (5.81 g/day), and children younger than 14 (2.83 g/day) represent the average per capita consumption of uncooked freshwater and estuarine fish for individuals in the United States population. The fish ingestion rates used as recreational angler default values for adults (17.5 g/day) and women of childbearing age (7.36 g/day) represent the 90th percentile per capita consumption of uncooked freshwater and estuarine fish for individuals in the United States population. The 90th percentile per capita fish consumption rate for children is 0.0 g/day (USEPA 2000a), therefore, children were not evaluated under the recreational angler exposure scenario. The fish ingestion rates used as subsistence angler default values for adults (142.4 g/day), women of childbearing age (109.72 g/day), and children younger than 14 (77.95 g/day) represent the 99th percentile per capita consumption of uncooked freshwater and estuarine fish for individuals in the United States population.

Individuals may find it difficult to assess their fish consumption in terms of grams per day. Two other common ways to present this information is in terms of 8-ounce fish meals over some period of time or in terms of pounds per year. Table 3-3 shows the fish consumption rates used in this risk assessment expressed in different units.

Table 3-3. Default fish consumption rates expressed in alternative units

	Consumption Unit		
Population Segment	Grams per Day	8-ounce Meals per Time Period	Pounds per Year
General Public			
Adult	7.5	12 meals/year	6.0
Women	5.81	10 meals/year	4.7
Children	2.83	5 meals/year	2.3
Recreational Anglers			
Adult	17.5	28 meals/year	14.1
Women	7.86	13 meals/year	6.3
Subsistence Anglers			
Adult	142.4	19 meals/month	114.6
Women	109.72	15 meals/month	88.3
Children	77.95	11 meals/month	62.7

Exposure Frequency

An exposure frequency of 365 day per year was assumed for calculations of the CDI. Oregon allows year-round fishing in the WFWF for carp, largescale sucker, and northern pikeminnow. The fishing season for smallmouth bass lasts 157 days, from April 1 through October 31 (ODFW 2000). An exposure frequency of 365 days per year was assumed for all fish species since anglers might catch and freeze fish for later consumption.

Exposure Duration

The exposure duration is the length of time over which exposure occurs at the concentration and ingestion rate specified by the other parameters in Equation 1. Specific information on the length of time over which anglers may be consuming fish from the WFWF reach of the Willamette River are not available. Two exposure durations, 30 years and 70 years, were assumed for calculations of the average adult CDI in this risk assessment. Thirty years is the national 90th percentile length of time that an individual stays at one residence (USEPA 1997c). Oregon ODEQ recommends a value of 30 years be used as a reasonable maximum exposure duration for adults, under a residential scenario, when preparing a deterministic human health risk assessment at cleanup sites in Oregon (ODEQ 1998). This default value is also recommended by USEPA (1989) as a reasonable maximum exposure duration when assessing the potential health risk of fish and shellfish ingestion under a residential exposure scenario.

A 70-year exposure duration was selected to assess the potential health risk of a lifetime exposure to chemicals detected in fish tissue. The average life expectancy of the general population in the United States is 72 years for males and 79 years for females (USEPA 1997d). USEPA (1997d) suggests that 75 years is an appropriate value to reflect the average life expectancy of the general population. A value of 70 years was selected as a lifetime exposure duration in this risk assessment because this value has been commonly used in other regional human health risk assessments of fish consumption (Tetra Tech 1996; USEPA 1999) and because USEPA's Integrated Risk Information System assumes a 70-year lifetime for the derivation of cancer slope factors (SFs) (USEPA 1997d).

An exposure duration of 30 years was used for women of childbearing age, which is considered to be from age 15 through age 44.

An exposure duration of 15 years was used to estimate the CDI of children. This exposure duration was selected for children in order to use recent national fish ingestion rate statistics for children, which provide ingestion data for children age 14 and younger (USEPA 2000).

Body Weight

The value for body weight in Equation 1 is the average body weight over the exposure period. A body weight of 70 kg was used to calculate adult CDI. This adult body weight is recommended as a default parameter for performing deterministic human health risk assessment at cleanup sites in Oregon (ODEQ 1998). USEPA (1997d) recommends that a body weight of 71.8 kg be used for adults; however, since USEPA's Integrated Risk Information System assumes a 70 kg adult body weight for the derivation of SFs (USEPA 1997d), the use of 70 kg avoids the necessity of having to adjust SFs to accommodate the 71.8 kg average body weight. The use of 70 kg as the default value for adult body weight also allows comparisons to made more readily with other regional human health risk assessments of fish consumption that also used 70 kg as default parameter for adult body weight (Tetra Tech, 1996; USEPA 1999).

A default body weight of 67 kg was used to calculate the CDI for women of childbearing age. This body weight corresponds to the average weight of females age 15 through 44 (USEPA 1997d).

A default body weight of 30 kg was used to calculate the CDI for children. This body weight corresponds to the average weight of female and male children ages 6 months to age 15 (USEPA 1997d).

Averaging Time

The averaging time for estimating carcinogenic risk was 25,550 days, the number of days in a 70-year exposure duration. The averaging time for assessing noncarcinogenic risk was the product of the exposure frequency and the exposure duration.

4.0 TOXICITY ASSESSMENT

The toxicity assessment evaluates each chemical's potential to cause health effects based on available toxicological information. However, toxicological information is not available for all chemicals. Chemicals without toxicity values are listed in Table 4-1. The potential health risks associated with exposure to these chemicals were not evaluated.

Toxicity information was obtained from USEPA toxicity databases, including Integrated Risk Information System (IRIS) and the fiscal year 1997 Health Effects Assessment Summary Tables (USEPA 1997b).

4.1 TOXICITY VALUES FOR NONCARCINOGENIC HEALTH ENDPOINTS

This section presents the toxicity values used to assess chronic health effects due to exposure from detected chemicals with noncarcinogenic endpoints. For each chemical, Table 4-2 presents the toxicity value used for evaluating exposure to noncarcinogens, defined as the reference dose (RfD), the confidence in the RfD, the uncertainty factor (UF), modifying factor (MF) associated with the RfD, and the critical health effects of each chemical. Several chemicals have more than one critical effect. The critical health effects are grouped into noncarcinogenic health endpoints, which are summarized in Table 4-3.

The RfD is an estimate (with uncertainty spanning perhaps an order of magnitude or greater) of the daily exposure to the human population, including sensitive sub-populations, that is likely to be without an appreciable risk of deleterious effects during a lifetime (USEPA 2000b). Table 4-2 also displays the confidence level in the RfD, a measure of uncertainty associated with the experimental procedure supporting the RfD; the UF, a measure of uncertainty associated within the data extrapolations for estimating the RfD (e.g., subchronic versus chronic study; rodent or primate versus human study); and MF, also based upon an evaluation of uncertainties of the data used to create an RfD, which typically ranges from 1–10 (USEPA 2000b).

Table 4-1. Chemicals without toxicity values

WITHOUT ORAL NONCARCINOGENIC AND CARCINOGENIC TOXICITY VALUES	WITHOUT ORAL NONCARCINOGENIC TOXICITY VALUES	WITHOUT ORAL CARCINOGENIC TOXICITY VALUE
Acenaphthylene	Aroclor 1242	Acenaphthene
Benzo(e)pyrene	Aroclor 1260	alpha-Endosulfan(I)
Benzo(ghi)perylene	alpha-HCH	Anthracene
Lead	beta-HCH	Antimony
Perylene	Benzo(bjk)fluoranthenes	Beryllium
Phenanthrene	Benz(a)anthracene	Cadmium
	Benzo(a)pyrene	Chromium
	Dibenz(ah)anthracene	Copper
	Chrysene	Endrin
	Indeno(1,2,3-cd)pyrene	Fluoranthene
	DDD (total)	Fluorene
	DDE (total)	Methoxychlor
		Naphthalene
	PCB Congeners:	Nickel
	3,3',4,4'-TCB (77)	Pyrene
	2',3,4,4',5-PeCB (123)	Silver
	2,3',4,4',5-PeCB (118)	Thallium
	2,3,4,4'5-PeCB (114)	
	2,3,3'4,4'-PeCB (105)	
	3,3'4,4',5-PeCB (126)	
	2,3',4,4',5,5'-HxCB (167)	
	2,3,3',4,4',5-HxCB(157)	
	2,3,3',4,4',5'-HxCB (156)	
	3,3',4,4',5,5'-HxCB (169)	
	2,2',3,4,4',5,5'-HpCB (180)	
	2,3,3',4',5,5',6-HpCB (193)	
	2,2',3,3',4,4',5-HpCB (170)	
	2,3,3',4,4',5,5'-HpCB (189)	
	Dioxins/Furans:	
	2,3,7,8-TCDD	
	1,2,3,7,8-PeCDD	
	1,2,3,4,7,8-HxCDD	
	1,2,3,6,7,8-HxCDD	
	1,2,3,7,8,9-HxCDD	
	1,2,3,4,6,7,8-HpCDD	
	OCDD	
	2,3,7,8-TCDF	
	1,2,3,7,8-PeCDF	
	2,3,4,7,8-PeCDF	
	1,2,3,4,7,8-HxCDF	
	1,2,3,6,7,8-HxCDF	
	1,2,3,7,8,9-HxCDF	
	2,3,4,6,7,8-HxCDF	
	1,2,3,4,6,7,8-HpCDF	
	1,2,3,4,7,8,9-HpCDF	
	OCDF	

SOURCE: IRIS (USEPA 2000b); HEAST (USEPA 1997b).

Table 4-2. Oral noncarcinogenic toxicity values

Chemical	Oral RfD (mg/kg-day)	Confidence	UF/MF	Critical Effect	Source
Acenaphthene	6.0E-02	Low	3000/1	Hepatotoxicity	USEPA 2000b
Aldrin	3.0E-05	Medium	1000/1	Liver toxicity	USEPA 2000b
Endosulfan[a]	6.0E-03	Medium	100/1	Reduced body wt. gain, increased incidence of marked progressive glomerulo-nephrosis in males	USEPA 2000b
Anthracene	3.0E-01	Low	3000/1	No observed effects	USEPA 2000b
Antimony	4.0E-04	Low	1000/1	Longevity, blood glucose, cholesterol	USEPA 2000b
Aroclor 1254	2.0E-05	Medium	300/1	Ocular exudate, inflamed and prominent Meibomian glands, distorted growth of finger- and toenails; decreased antibody (IgG and IgM) response to sheep erythrocytes	USEPA 2000b
Arsenic, inorganic[b]	3.0E-04	Medium	3/1	Hyperpigmentation, keratosis and possible vascular complications	USEPA 2000b
Beryllium	2.0E-03	Low to Medium	300/1	Small intestinal lesions	USEPA 2000b
Cadmium	1.0E-03	High	10/1	Significant proteinuria	USEPA 2000b
Chlordane (total)[c]	5.0E-04	Medium	300/1	Hepatic necrosis	USEPA 2000b
Chromium (VI)	3.0E-03	Low	300/3	None reported	USEPA 2000b
Copper	3.7E-02	–	–	–	USEPA 1997b
Dieldrin	5.0E-05	Medium	100/1	Liver lesions	USEPA 2000b
DDT[d]	5.0E-04	Medium	100/1	Liver lesions	USEPA 2000b
Endrin	3.0E-4	Medium	100/1	Mild histological lesions in liver, occasional convulsions	USEPA 2000b
Fluoranthene	4.0E-02	Low	3000/1	Nephropathy, increased liver weights, hematological alterations, and clinical effects	USEPA 2000b
Fluorene	4.0E-02	Low	3000/1	Decreased red blood cell, packed cell volume and hemoglobin	USEPA 2000b
gamma-HCH (Lindane)	3.0E-04	Medium	1000/1	Liver and kidney toxicity	USEPA 2000b
Heptachlor	5.0E-04	Low	300/1	Liver weight increases in males	USEPA 2000b
Heptachlor epoxide	1.3E-05	Low	1000/1	Increased liver-to-body weight ratio in both males and females	USEPA 2000b
Hexachlorobenzene	8.0E-04	Medium	100/1	Liver effects	USEPA 2000b
Methylmercury[e]	1.0E-04	Medium	10/1	Developmental neurological abnormalities in human infants	USEPA 2000b
Methoxychlor	5.0E-03	Low	1000/1	Excessive loss of litters	USEPA 2000b

Table 4-2, continued

CHEMICAL	ORAL RFD (mg/kg-day)	CONFIDENCE	UF/MF	CRITICAL EFFECT	SOURCE
Mirex	2.0E-04	High	300/1	Liver cytomegaly, fatty metamorphosis, angiectasis; thyroid cystic follicles	USEPA 2000b
Naphthalene	2.0E-02	Low	3000/1	Decreased average terminal body weight in males	USEPA 2000b
Nickel, soluble salts	2.0E-02	Medium	300/1	Decreased body and organ weights	USEPA 2000b
Pyrene	3.0E-02	Low	3000/1	Kidney effects (renal tubular pathology, decreased kidney weights)	USEPA 2000b
Silver	5.0E-03	Low	3/1	Argyria	USEPA 2000b
Thallium[f]	9.0E-05	Low	3000/1	Increased levels of SGOT[g] and LDH[h]	USEPA 2000b
Zinc	3.0E-01	Medium	3/1	47% decrease in erythrocyte superoxide dismutase (ESOD) concentration in adult females after 10 weeks of zinc exposure	USEPA 2000b

SOURCE: IRIS 2000 (USEPA 2000b); HEAST 1997 (USEPA 1997b)

NOTE: RfD = chronic reference dose for assessing noncarcinogenic health effects
UF = uncertainty factor
MF = modifying factor

[a] Alpha-endosulfan(I) analyzed in study.
[b] Arsenic and total inorganic arsenic measured.
[c] Cis-chlordane, cis-nonachlor, oxychlordane, trans-chlordane, and trans-nonachlor summed for chlordane (total).
[d] Toxicity value for p,p'-DDT used.
[e] Reported as mercury in data set.
[f] Toxicity value based on thallium nitrate
[g] Serum glutamic oxaloacetic transaminase.
[h] LDH-lactate dehydrogenase

Table 4-3. Noncarcinogenic health endpoints associated with chemical analytes

Group	Analyte	Health Endpoint											
		Metabolic	Hematopoietic	Immunological	Cardiovascular	Renal	Hepatic	Neurological	Reproductive/ Developmental	Intestinal Lesions	Argyria	Thyroid	Other
Metals	Antimony	✔			●		●	●					
	Arsenic				✔	●		●					
	Beryllium									✔			
	Cadmium					✔		●					
	Mercury							✔	✔				
	Nickel	✔											●
	Silver					●	●				✔		
	Thallium	●			●	●	✔	●					●
	Zinc	✔											
PAHs	Acenaphthene						✔						
	Fluoranthene		✔			✔	✔						
	Fluorene		✔										
	Hexachlorobenzene						✔						
	Naphthalene	✔											
	Pyrene					✔							
Pesticides	Aldrin						✔	●	●				
	Chlordane (total)	●					✔	●					
	DDT [a]				●		✔	●	●				
	Dieldrin						✔	●	●				
	alpha-Endosulfan(I)	✔			✔	✔		●	●				
	Endrin						✔	✔					
	gamma-HCH					✔	✔	●					
	Heptachlor						✔						
	Heptachlor epoxide						✔	●	●				
	Methoxychlor	●			●				✔				●
	Mirex						✔	●	●			✔	
PCBs	Total Aroclors [b]			✔			●	●	●				

NOTE: ✔ = Chronic reference dose is based on the health endpoint
● = Other health endpoints

[a] Comprised of DDE, DDD, and DDT.
[b] Sum of Aroclor 1242, Aroclor 1254, and Aroclor 1260.

One class of chemicals, dioxins and furans, is not included in Tables 4-2 and 4-3, although noncarcinogenic endpoints are known to exist. The noncarcinogenic effects of dioxins and furans are currently under review by USEPA. The effect of the absence of an RfD for dioxin on the overall hazard estimates is discussed in Section 6.0.

The noncarcinogenic risk estimate for the majority of chemicals was based on chemical-specific toxicity values (RfDs). For two chemical groups, Aroclors and DDT and its derivatives, an RfD for one chemical within the group was applied to other chemicals within the group that do not currently have associated RfD values. A discussion of the calculations and justification for the treatment of these groups are discussed below.

Three Aroclors were measured in fish samples (Aroclor 1242, Aroclor 1254, and Aroclor 1260), but only Aroclor 1254 has an associated RfD value. In order to calculate the hazard quotient (HQ) for the immunological health endpoint, which is based on the toxicity of Aroclors (Table 4-2), two possible approaches for the estimation of immunological risk were available:

- Approach 1: the HQ could be estimated by summing the concentrations of all three Aroclors for each sample and utilizing the RfD for Aroclor 1254 to estimate risk.

- Approach 2: the HQ could be estimated using the concentration of Aroclor 1254 only for each sample and the RfD for Aroclor 1254 could be utilized to estimate risk.

The first approach was taken to provide a conservative evaluation of the risk from Aroclors by including data from Aroclor 1242 and Aroclor 1260. A quantitative comparison between the two approaches is discussed in the Uncertainty Evaluation, Section 6.0.

DDT and its derivatives, DDD and DDE, were measured in fish tissue samples. Similar to Aroclors, only DDT has an RfD value. In order to calculate an HQ for the hepatic endpoint (Table 4-2), which includes DDT, the two same approaches for Aroclors discussed above could be applied to DDT and its derivatives. For the risk estimate, the conservative approach was used. This required the summation of DDT, DDD, and DDE concentrations per sample and the use of the RfD associated with DDT to calculate an HQ for total DDT. This value was then summed with HQs from the other contributing chemicals to derive a hazard index (HI) for the hepatic endpoint. A comparison of HQs and the hepatic HI using both approaches is discussed in Section 6.0.

4.2 TOXICITY VALUES FOR CARCINOGENIC HEALTH ENDPOINTS

This section presents toxicity values used to assess potential carcinogenic effects. For each detected chemical, the SF, and its associated potential for carcinogenicity in humans, as expressed by the USEPA classification as weight-of-evidence, are presented (Tables 4-4 and 4-5). The SF is based on a dose-response curve using available carcinogenic data for a given chemical. Mathematical models are used to extrapolate from high experimental doses to the low doses expected for human contact in the environment. These models assume that there is no concentration below which the probability of a carcinogenic response is zero. This mechanism for carcinogenesis is referred to as "nonthreshold." Based upon the evaluation of human and animal studies, each chemical falls into one of the following five USEPA-defined classes:

Table 4-4. USEPA weight-of-evidence classifications for carcinogens

WEIGHT-OF-EVIDENCE CLASSIFICATION	CATEGORY
A	Human carcinogen
B	Probable human carcinogen
	B1 – Limited human evidence B2 – Sufficient evidence in animals, no human evidence
C	Possible human carcinogen
D	Not classifiable as a human carcinogen
E	Evidence of noncarcinogenicity in humans

SOURCE: USEPA (2000b).

Table 4-5. Oral carcinogenic toxicity values

CHEMICAL	CANCER SLOPE FACTOR (kg-d/mg)	WEIGHT OF EVIDENCE	TUMOR TYPE	SOURCE
2,3,7,8-TCDD	1.6E+05	B2	Respiratory system and liver tumors	USEPA 1984
Aldrin	1.7E+01	B2	Liver carcinoma	USEPA 2000b
alpha-HCH (alpha-BHC)	6.3E+00	B2	Liver tumors	USEPA 2000b
Aroclor 1242	2.0E+00	B2	Hepatocellular carcinomas	USEPA 1996a
Aroclor 1254	2.0E+00	B2	Hepatocellular carcinomas	USEPA 1996a
Aroclor 1260	2.0E+00	B2	Hepatocellular carcinomas	USEPA 1996a
Arsenic, inorganic	1.5E+00	A	Skin cancer, internal organs (liver, kidney, lung, bladder)	USEPA 2000b
Benzo(a)pyrene	7.3E+00	B2	Forestomach, squamous cell papillomas and carcinomas	USEPA 2000b
beta-HCH (beta-BHC)	1.8E+00	C	Benign liver tumors	USEPA 2000b
Chrysene	7.3E-03	B2	Carcinoma and malignant lymphoma	USEPA 2000b
Chlordane (total)[a]	3.5E-01	B2	Non-Hodgkin's lymphoma and liver tumors	USEPA 2000b
Dieldrin	1.6E+01	B2	Liver carcinoma	USEPA 2000b
Heptachlor	4.5E+00	B2	Hepatic nodules and hepatocellular carcinomas	USEPA 2000b
Heptachlor epoxide	9.1E+00	B2	Liver carcinoma	USEPA 2000b
Hexachlorobenzene	1.6E+00	B2	Liver, thyroid, kidney tumors	USEPA 2000b
gamma-HCH (Lindane)	1.3E+00	B2-C	Liver tumors	USEPA 1997b
DDD (total)[b]	2.4E-01	B2	Lung, liver, and thyroid tumors	USEPA 2000b
DDE (total)[b]	3.4E-01	B2	Liver and thyroid tumors	USEPA 2000b
DDT (total)[b]	3.4E-01	B2	Liver	USEPA 2000b

SOURCE: USEPA 2000b (IRIS) and USEPA 1997b (HEAST)

[a] Chlordane (total) is the sum of alpha-chlordane, cis-nonachlor, gamma-chlordane, oxychlordane, and trans-nonachlor.

[b] Slope factor based on p,p' isomers.

The toxicity of dioxins, furans, and dioxin-like congeners were evaluated using toxicity equivalency factors (TEFs) recommended by the World Health Organization (Van den Berg et al 1998). This procedure utilizes a set of TEFs derived from 2,3,7,8-TCDD to convert the concentration of any dioxin, furan, or dioxin-like congener into an equivalent concentration of 2,3,7,8-TCDD. Table 4-6 presents a list of the 17 2,3,7,8-substituted dioxin and furan congeners and 14 dioxin-like PCB congeners with 2,3,7,8-TCDD TEF values.

Table 4-6. Toxicity equivalency factors for PCB congeners and dioxin and furan congeners

Group	Chemical	Toxicity Equivalency Factor[a]
PCBs	3,3',4,4'-TeCB (77)	0.0001
	2',3,4,4',5-PeCB (123)	0.0001
	2,3',4,4',5-PeCB (118)	0.0001
	2,3,4,4'5-PeCB (114)	0.0005
	2,3,3'4,4'-PeCB (105)	0.0001
	3,3'4,4',5-PeCB (126)	0.1
	2,3',4,4',5,5'-HxCB (167)	0.00001
	2,3,3',4,4',5-HxCB(157)	0.0005
	2,3,3',4,4',5'-HxCB (156)	0.0005
	3,3',4,4',5,5'-HxCB (169)	0.01
	2,2',3,4,4',5,5'-HpCB (180)	0
	2,3,3',4',5,5',6-HpCB (193)	0
	2,2',3,3',4,4',5-HpCB (170)	0
	2,3,3',4,4',5,5'-HpCB (189)	0.0001
Dioxins	2,3,7,8-TCDD	1
	1,2,3,7,8-PeCDD	1
	1,2,3,4,7,8-HxCDD	0.1
	1,2,3,6,7,8-HxCDD	0.1
	1,2,3,7,8,9-HxCDD	0.1
	1,2,3,4,6,7,8-HpCDD	0.01
	OCDD	0.0001
Furans	2,3,7,8-TCDF	0.1
	1,2,3,7,8-PeCDF	0.05
	2,3,4,7,8-PeCDF	0.5
	1,2,3,4,7,8-HxCDF	0.1
	1,2,3,6,7,8-HxCDF	0.1
	1,2,3,7,8,9-HxCDF	0.1
	2,3,4,6,7,8-HxCDF	0.1
	1,2,3,4,6,7,8-HpCDF	0.01
	1,2,3,4,7,8,9-HpCDF	0.01
	OCDF	0.0001

[a] World Health Organization (Van den Berg et al. 1998).

For this risk assessment, two different measures of PCBs were analyzed: Aroclors, commercial mixtures of PCBs that are no longer being manufactured (USEPA 1996a), and PCB congeners. Three Aroclors were measured in fish tissues: Aroclor 1242, Aroclor

1254, and Aroclor 1260. In addition, ten PCB congeners were measured that exert toxicity similar to 2,3,7,8-TCDD (dioxin-like PCBs). PCB 170 and PCB 180 were not considered dioxin-like PCB congeners because they currently do not have associated TEF values. Because Aroclors are a mixture of both dioxin-like and non-dioxin-like congeners, calculating and summing the risk associated with both Aroclors and with individual PCBs would likely overestimate carcinogenic risk by accounting for PCB congener risk both at the individual level and from Aroclors. Therefore, an adjustment was made to Aroclors by subtracting the concentration of dioxin-like congeners from the total Aroclor concentration for each sample in order to calculate an adjusted Aroclor concentration which estimates non-dioxin-like PCBs. This method has been suggested by USEPA as an approach to improve risk estimates based on available data (USEPA 1996a).

The toxicity of four PAH compounds was evaluated relative to the toxicity of benzo(a)pyrene. The SF for benzo(a)pyrene is used with the adjusted toxic equivalent concentration (TEC) to determine the risk. TEFs are shown in Table 4-7. The use of PAH TEFs is consistent with Oregon Environmental Cleanup Guidelines (ODEQ web site 2000).

Table 4-7. Toxic equivalency factors for PAHs

Chemical	Toxicity Equivalency Factor
Benz(a)anthracene	0.1
Benzo(a)pyrene	1
Benzo(bjk)fluoranthenes	0.1[a]
Dibenz(a,h)anthracene	1
Indeno(1,2,3-cd)pyrene	0.1

SOURCE: USEPA (1993)

[a] Based on the more conservative TEF for benzo(b)fluoranthene

5.0
RISK CHARACTERIZATION

Risk characterization integrates the results of the exposure assessment with chemical toxicity information to derive estimates of individual health risks potentially resulting from the exposure pathways. Section 5.1 describes the equations used to quantify potential noncarcinogenic health effects and the probabilities that an individual will develop cancer over their lifetime due to the exposure scenarios assumed for this risk assessment. Section 5.2 characterizes the potential health risks to the target populations identified in Section 3.0.

5.1 RISK CHARACTERIZATION EQUATIONS

Noncarcinogenic and carcinogenic risk estimates are calculated separately because of fundamental differences in their critical toxicity values. Equations used to derive risk estimates for both types of health effects are presented below.

5.1.1 Noncarcinogenic Health Effects

The potential for noncarcinogenic health effects is evaluated by calculating the ratio of the chemical exposure over a specified time period to an RfD that is derived for a similar time period. This ratio of exposure to toxicity for an individual chemical is called the hazard quotient (HQ):

$$HQ = \frac{CDI}{RfD} \qquad \text{(Equation 3)}$$

Where:

HQ = Chemical-specific hazard quotient (unitless)
CDI = Chemical-specific chronic daily intake (mg/kg-day)
RfD = Route- and chemical-specific reference dose (mg/kg-day)

The noncarcinogenic HQ assumes that there is a threshold level of exposure, the RfD, below which it is unlikely that even sensitive populations will experience adverse health effects (USEPA 1989). If the exposure exceeds this threshold (HQ > 1), there may be concern for potential noncarcinogenic health effects. Generally, the greater the magnitude of the HQ above a value of 1, the greater the level of concern for noncarcinogenic health effects. It should be noted, however, that exposures above the RfD do not represent the same increase in risk for all chemicals as RfDs do not have equal accuracy or precision and are not based on the same severity of toxic effects (USEPA 1989; Hayes 1994). Furthermore, the level of concern does not increase linearly as the RfD is approached.

The HQ values presented in this risk assessment evaluate chronic exposure durations, which in humans are defined as ranging in duration from seven years to a lifetime (USEPA 1989). Subchronic exposures of two weeks to seven years or shorter-term exposures are not evaluated in this risk assessment.

To assess the overall potential for noncarcinogenic health effects posed by exposure to multiple chemicals in fish tissue, the HQ values for chemicals with similar target organs or mechanisms of action (health endpoints) were summed to calculate an HI. An HI is an estimate of the cumulative potential for noncarcinogenic effects due to exposure from multiple chemicals for a specific human health endpoint (USEPA 1986). A total of eleven noncarcinogenic health endpoints were evaluated in this assessment: metabolic, hematopoietic, immunological, cardiovascular, renal, hepatic, neurological, reproductive/developmental, intestinal lesions, thyroid, and argyria (Table 4-3).

A total HI value was also calculated by summing all HQ values for individual chemicals regardless of health endpoint. This value, while it has little basis from a toxicological point of view because it violates assumptions of dose additivity, is appropriate for screening-level assessments of noncarcinogenic health risk (USEPA 1989).

The Oregon Health Division uses the HQ methodology to calculate noncarcinogenic risk for individuals who consume fish harvested from state waters (EVS 2000a). A nHQ greater than 1.0 is typically used as the basis for issuing fish consumption advisories. In this risk assessment an HI of 1.0 for health endpoints that include multiple chemicals, or an HQ of 1.0 for health endpoints that include only a single chemical, is used as a threshold for determining whether the exposures have a potential to cause adverse noncarcinogenic health effects.

The reproductive/developmental endpoint was not assessed for adults, but rather was restricted to women of childbearing age (15-44 years) and to children, because this is the subset of the population most likely to be affected by adverse reproductive/developmental health effects.

5.1.2 Carcinogenic Risk

Risk for carcinogens is estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen (USEPA 1989). Under current risk assessment guidelines, USEPA assumes that a threshold dose does not exist for carcinogens and that any dose can contribute to health risks (USEPA 1997a). In other words, the risk of cancer is proportional to dose exposure and there is never a zero probability of cancer risk when exposed to carcinogenic chemicals. Carcinogenic risk probabilities were calculated by multiplying the estimated exposure level by the SF for each chemical. This product represents the excess cancer risk, or the additional risk that an individual has of developing cancer in their lifetime due to exposure to a particular toxic substance.

$$\text{Risk} = \text{CDI} \times \text{SF} \qquad \text{(Equation 4)}$$

where:

Risk = Estimated chemical-specific individual excess lifetime cancer risk (unitless)

CDI = Chemical-specific chronic daily intake (mg/kg-day)

SF = Route- and chemical-specific cancer slope factor (kg-day/mg)

The excess cancer risk estimates in this report are shown in scientific notation format. These values, for example 1.0E-06, should be interpreted as an increased risk of 1.0 in 1 million of developing cancer over a lifetime. The interpretation of cancer risk estimates requires that an individual determine what increased risk is acceptable. This threshold is referred to as the acceptable risk level (ARL) (USEPA 1997a). Eleven states currently use 1.0E–04 (1 in 10,000), fourteen states use 1.0E-05 (1 in 100,000), and eight states use 1.0E-06 (1 in 1,000,000) as the ARL for issuing state fish consumption advisories (EVS 2000a). The Oregon Health Division has used an ARL of 1.0E-06 for some carcinogens to issue fish advisories within the state (EVS 2000a). For this risk assessment, an individual lifetime excess cancer risk of 1.0E-06 was used as the ARL to assess the potential for adverse health effects due to ingestion of fish containing carcinogenic chemicals.

To assess the risk posed by simultaneous exposure to multiple carcinogenic chemicals in fish tissue, the excess cancer risk for all carcinogenic chemicals was summed to calculate a total cancer risk.

5.2 RISK CHARACTERIZATION

Exposure parameters were selected to estimate risk to three target populations referred to as the general public, recreational anglers, and subsistence anglers (see Section 3.0). Exposure parameters for these three groups differed only for the rate of fish consumption; the rate was lowest for the general public and highest for subsistence anglers. Within each target population, risk estimates were determined for adults, defined as individuals of age 18 or greater, women of childbearing age, defined as females of age 15-44; and children, defined as age 14 and younger. Exposure parameters for adults, childbearing women, and children differed for the rate of fish consumption, body weight, and exposure duration (Table 3-2). The noncarcinogenic and excess cancer risk estimates for these target populations are presented in the following sections. Separate risk estimates are provided for each fish species and tissue analyzed in this study.

5.2.1 Chemicals Not Evaluated

A total of 85 chemicals were selected for analysis in this risk assessment. Two of these chemicals, thallium and heptachlor, were never detected in the tissue of any fish samples and were not evaluated (Table 5-1). Six chemicals did not have RfD or SF toxicity values and also were not evaluated in this risk assessment (Table 4-1).

Table 5-1. Chemicals never detected in tissue samples analyzed in this study

	Bass	Carp		Pikeminnow		Sucker	
Chemical	Fillet	Fillet	Whole Body	Fillet	Whole Body	Fillet	Whole Body
Metals							
Antimony	✔	✔		✔	✔	✔	
Arsenic				✔	✔		
Arsenic-total inorganic		✔		✔	✔		
Beryllium	✔	✔				✔	
Cadmium	✔	✔		✔		✔	
Chromium							
Copper							
Lead	✔	✔		✔		✔	
Mercury							
Nickel		✔					
Silver	✔	✔		✔	✔		
Thallium	✔	✔	✔	✔	✔	✔	✔
Zinc							
PAHs							
Acenaphthene		✔		✔			
Acenaphthylene		✔		✔			
Anthracene	✔	✔		✔			
Benz(a)anthracene	✔	✔		✔	✔	✔	
Benz(bjk)fluoranthene	✔	✔		✔	✔		
Benzo(a)pyrene	✔	✔		✔	✔	✔	
Benzo(e)pyrene	✔	✔		✔	✔	✔	
Benzo(ghi)perylene	✔	✔		✔		✔	
Chrysene	✔	✔		✔	✔	✔	
Dibenz(a,h)anthracene	✔	✔	✔	✔		✔	✔
Fluoranthene		✔					
Fluorene	✔	✔		✔			
Indeno(1,2,3-cd) pyrene	✔	✔		✔		✔	
Perylene	✔	✔		✔	✔	✔	
Phenanthrene						✔	
Pesticides							
Aldrin	✔					✔	
Alpha-HCH	✔	✔		✔		✔	
alpha-Endosulfan(I)	✔	✔		✔	✔	✔	✔
beta-HCH	✔	✔		✔		✔	
cis-Chlordane						✔	

Table 5-1, continued

	Bass	Carp		Pikeminnow		Sucker	
Chemical	Fillet	Fillet	Whole Body	Fillet	Whole Body	Fillet	Whole Body
Pesticides, continued							
cis-Nonachlor						✔	
Endrin	✔	✔		✔	✔	✔	✔
gamma-HCH						✔	
Heptachlor	✔	✔	✔	✔	✔	✔	✔
Heptachlor epoxide	✔			✔			
Hexachlorbenzene						✔	
Methoxychlor	✔	✔		✔		✔	✔
Mirex						✔	
o,p'-DDD						✔	
o,p'-DDE						✔	
o,p'-DDT						✔	
Oxychlordane	✔			✔		✔	
trans-Chlordane						✔	
trans-Nonachlor						✔	
PCBs							
33'44'5-PeCB (126)						✔	
Aroclor 1242				✔		✔	
Aroclor 1254						✔	
Aroclor 1260						✔	
Dioxins/Furans							
2,3,7,8-TCDD							
1,2,3,7,8-PeCDD							
1,2,3,4,7,8-HxCDD	✔			✔		✔	
1,2,3,6,7,8-HxCDD	✔			✔		✔	
1,2,3,7,8,9-HxCDD	✔			✔		✔	
1,2,3,4,6,7,8-HpCDD	✔						
OCDD							
2,3,7,8-TCDF							
1,2,3,7,8-PeCDF				✔		✔	
2,3,4,7,8-PeCDF						✔	
1,2,3,4,7,8-HxCDF				✔		✔	
1,2,3,6,7,8-HxCDF	✔	✔		✔		✔	
1,2,3,7,8,9-HxCDF	✔	✔	✔	✔	✔	✔	
2,3,4,6,7,8-HxCDF	✔			✔		✔	
1,2,3,4,6,7,8-HpCDF	✔	✔		✔		✔	
1,2,3,4,7,8,9-HpCDF	✔	✔	✔	✔	✔	✔	
OCDF							

5.2.2 Noncarcinogenic Health Effects

Health effects for noncarcinogenic health endpoints were evaluated for three target populations using the exposure assumptions discussed in Section 3.0. Health effects for these target populations are discussed in the following sections.

General Population

Noncarcinogenic health effects for the adult general population scenario are shown in Table 5-2a. HI values for all 11 noncarcinogenic health endpoints were less than 1.0. These results suggest that the exposure represented by this scenario does not pose an unacceptable noncarcinogenic health risk to adults.

Table 5-2a. Total noncarcinogenic hazard indices for the general population—adults with a fish ingestion rate of 7.5 g/day (12 8-oz meals/year)

	Bass	Carp		Pikeminnow		Sucker	
Endpoint	Fillet	Fillet	Whole Body	Fillet	Whole Body	Fillet	Whole Body
Metabolic[a]	0.003	0.01	0.03	0.003	0.005	0.003	0.006
Hematopoietic[b]	0.000001	nd	0.000007	0.000001	0.000006	0.000003	0.000008
Immunological[c]	0.1	0.4	0.8	0.2	0.5	nd	0.6
Cardiovascular[d]	0.001	nd	0.002	nd	nd	0.001	0.007
Renal[e]	0.0003	0.000002	0.002	0.000005	0.001	0.000008	0.001
Hepatic[f]	0.005	0.05	0.06	0.007	0.03	0.007	0.04
Neurological[g]	0.4	0.3	0.1	0.8	0.4	0.2	0.1
Intestional lesions[h]	nd	nd	0.0001	0.0001	0.00004	nd	0.0004
Argyria[i]	nd	nd	0.0004	nd	nd	0.0004	0.0004
Thyroid[j]	0.00002	nd	0.00008	nd	0.00008	nd	nd
Total HI[k]	0.6	0.7	1.0	1.0	1.0	0.2	0.8

NOTE: HI = hazard index
nd = chemical(s) with this health endpoint were not detected

Chemicals contributing to hazard index were:
- [a] antimony, nickel, zinc, endosulfan(I), and naphthalene
- [b] fluoranthene and fluorene
- [c] Aroclors
- [d] total inorganic arsenic and endosulfan(I)
- [e] endosulfan(I), gamma HCH, fluoranthene, pyrene, and cadmium
- [f] hexachlorobenzene, heptachlor epoxide, gamma HCH, mirex, fluoranthene, acenaphthene, aldrin, dieldrin, chlordane (total), DDT (comprised of DDE, DDD, and DDT), endrin, thallium, and heptachlor
- [g] mercury and endrin
- [h] beryllium
- [i] silver
- [j] mirex
- [k] The sum of HQs for all noncarcinogenic chemicals regardless of endpoint

Reproductive/developmental health effects for women of childbearing age for the general population scenario are shown in Table 5-2b. HI values for all fish species and sample types are less than 1.0. These results suggest that the exposure represented by this scenario does not pose an unacceptable risk to women of childbearing age.

Table 5-2b. Total noncarcinogenic hazard indices for the general population—women of childbearing age with a fish ingestion rate of 5.81 g/day (10 8-oz meals/year)

	Bass	Carp		Pikeminnow		Sucker	
Endpoint	Fillet	Fillet	Whole Body	Fillet	Whole Body	Fillet	Whole Body
Reproductive/ developmental	0.3	0.2	0.1	0.6	0.3	0.1	0.1
Total HI[a]	0.4	0.6	0.8	0.8	0.8	0.2	0.6

NOTE: HI = hazard index
Women of reproductive age (15-44 years) and a body weight of 67 kg
Chemicals contributing to hazard index were mercury and methoxychlor

[a] The sum of HQs for all noncarcinogenic chemicals regardless of endpoint

Noncarcinogenic risk estimates for the children general population scenario are shown in Table 5-2c. HI values for all 11 noncarcinogenic health endpoints were less than 1.0. These results suggest that the exposure represented by this scenario does not pose an unacceptable noncarcinogenic health risk to children of age 14 and younger.

Table 5-2c. Total noncarcinogenic hazard indices for the general population—children with a fish ingestion rate of 2.83 g/day (5 8-oz meals/year)

	Bass	Carp		Pikeminnow		Sucker	
Endpoint	Fillet	Fillet	Whole Body	Fillet	Whole Body	Fillet	Whole Body
Metabolic[a]	0.003	0.009	0.03	0.002	0.004	0.003	0.006
Hematopoietic[b]	0.000001	nd	0.000006	0.000001	0.000005	0.000002	0.000007
Immunological[c]	0.1	0.3	0.7	0.2	0.5	nd	0.5
Cardiovascular[d]	0.001	nd	0.002	nd	nd	0.001	0.006
Renal[e]	0.0002	0.000002	0.002	0.000004	0.001	0.000007	0.0008
Hepatic[f]	0.005	0.04	0.05	0.006	0.02	0.006	0.03
Neurological[g]	0.4	0.2	0.1	0.7	0.3	0.2	0.1
Developmental[h]	0.4	0.2	0.1	0.7	0.3	0.2	0.1
Intestional lesions[i]	nd	nd	0.00009	0.00009	0.00003	nd	0.0003
Argyria[j]	nd	nd	0.0004	nd	nd	0.0004	0.0004
Thyroid[k]	0.00008	nd	0.00007	nd	0.00008	nd	nd
Total HI[l]	0.5	0.6	0.9	0.8	0.8	0.2	0.7

NOTE: HI = hazard index
Children of age 0-14 years and a body weight of 30 kg.
nd = chemical(s) with this health endpoint were not detected

Chemicals contributing to hazard index were:
[a] antimony, nickel, zinc, endosulfan(I), and naphthalene
[b] fluoranthene and fluorene
[c] Aroclors
[d] total inorganic arsenic and endosulfan(I)
[e] endosulfan(I), gamma HCH, fluoranthene, pyrene, and cadmium
[f] hexachlorobenzene, heptachlor epoxide, gamma HCH, mirex, fluoranthene, acenaphthene, aldrin, dieldrin, chlordane (total), DDT (comprised of DDE, DDD, and DDT), endrin, thallium, and heptachlor
[g] mercury and endrin
[h] mercury and methoxychlor
[i] beryllium
[j] silver
[k] mirex
[l] The sum of HQs for all noncarcinogenic chemicals regardless of endpoint

Recreational Anglers

Noncarcinogenic risk estimates for the adult recreational angler population scenario are shown in Table 5-3a. HI values exceeded 1.0 for immunological effects for whole-body tissue samples from carp (1.8), pikeminnow (1.3), and sucker (1.4). The HI calculated for pikeminnow fillet (1.8) also exceeded a value of 1.0. All HI values for fillet tissue from bass, carp, and sucker were less than 1.0. These results suggest that the exposure represented by this scenario does not pose unacceptable noncarcinogenic health risk to adults consuming only fillet tissue from bass, carp, or sucker. Both tissue types of pikeminnow had HI values that exceeded a value of 1.0. These values may be of concern for potential health effects to immunological and neurological health endpoints.

Reproductive/developmental risks to women of childbearing age for the recreational angler population scenario are shown in Table 5-3b. HI values for all fish species and sample types are less than 1.0. These results suggest that the exposure represented by this scenario does not pose an unacceptable risk to women of childbearing age.

Table 5-3a. Total noncarcinogenic hazard indices for recreational anglers—adults with a fish ingestion rate of 17.5 g/day (28 8-oz meals/year)

	Bass	Carp		Pikeminnow		Sucker	
Endpoint	Fillet	Fillet	Whole Body	Fillet	Whole Body	Fillet	Whole Body
Metabolic[a]	0.008	0.02	0.07	0.006	0.01	0.007	0.01
Hematopoietic[b]	0.000003	nd	0.00002	0.000003	0.00001	0.000006	0.00002
Immunological[c]	0.3	0.9	[redacted]	0.4	[redacted]	nd	[redacted]
Cardiovascular[d]	0.003	nd	0.005	nd	nd	0.003	0.02
Renal[e]	0.0007	0.000004	0.005	0.00001	0.003	0.00002	0.002
Hepatic[f]	0.01	0.1	0.1	0.02	0.07	0.02	0.08
Neurological[g]	0.9	0.6	0.3	[redacted]	0.9	0.4	0.3
Intestional lesions[h]	nd	nd	0.0002	0.0002	0.00009	nd	0.0008
Argyria[i]	nd	nd	0.001	nd	nd	0.001	0.001
Thyroid[j]	0.00006	nd	0.0002	nd	0.0002	nd	nd
Total HI[k]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

NOTE: HI = hazard index
nd = chemical(s) with this health endpoint were not detected
[redacted] values exceed 1.0

Chemicals contributing to hazard index were:

- [a] antimony, nickel, zinc, endosulfan(I), and naphthalene
- [b] fluoranthene and fluorene
- [c] Aroclors
- [d] total inorganic arsenic and endosulfan(I)
- [e] endosulfan(I), gamma HCH, fluoranthene, pyrene, and cadmium
- [f] hexachlorobenzene, heptachlor epoxide, gamma HCH, mirex, fluoranthene, acenaphthene, aldrin, dieldrin, chlordane (total), DDT (comprised of DDE, DDD, and DDT), endnn, thallium, and heptachlor
- [g] mercury and endrin
- [h] beryllium
- [i] silver
- [j] mirex
- [k] The sum of HQs for all noncarcinogenic chemicals regardless of endpoint

Table 5-3b. Total noncarcinogenic hazard indices for recreational anglers—women of childbearing age with a fish ingestion rate of 7.86 g/day (13 8-oz meals/year)

Endpoint	Ingestion Rate[a] (g/d)	Bass	Carp		Pikeminnow		Sucker	
		Fillet	Fillet	Whole Body	Fillet	Whole Body	Fillet	Whole Body
Reproductive/ developmental	7.36	0.4	0.3	0.1	0.8	0.4	0.2	0.1
Total HI[a]	7.36	0.6	0.7	[illegible]	1.0	1.0	0.2	0.8

NOTE: HI = hazard index
Shaded values exceed 1.0
Women of reproductive age (15-44 years) and a body weight of 67 kg
Chemicals contributing to hazard index were mercury and methoxychlor

[a] The sum of HQs for all noncarcinogenic chemicals regardless of endpoint

Subsistence Anglers

Noncarcinogenic risk estimates for the adult subsistence angler population scenario are shown in Table 5-4a. HI values exceeded 1.0 for all fish species and tissue types for the neurological health endpoint. HI values also exceeded 1.0 for the immunological health endpoint for all tissue types and fish species except sucker tissue. Carp whole-body tissue also had an HI exceeding 1.0 for the hepatic health endpoint. The health endpoint with the maximum HI value tended to vary by tissue type. The immunological health endpoint had the highest HI for all whole-body samples and carp fillet. The neurological health endpoints had the highest HI values for all fillet samples except carp fillet. The maximum HI values under this scenario ranged from 3.3 to 15 for fillet samples and from 10 to 15 for whole-body samples. These values may be of concern for potential noncarcinogenic health effects to immunological and neurological health endpoints.

Reproductive/developmental risks to women of childbearing age for the subsistence angler population scenario are shown in Table 5-4b. HI values for all fish species and sample types exceeded a value of 1.0. HI values for fillet tissue ranged from 2.7 to 12, while values for whole-body tissue ranged from 1.9 to 5.6. These results suggest that the exposure represented by this scenario may pose an unacceptable risk to women of childbearing age.

Noncarcinogenic risk estimates for the children subsistence angler population scenario are shown in Table 5-4c. HI values exceeded a value of 1.0 for immunological, neurological, and developmental health endpoints in all species and sample types except sucker fillet, which exceeded a value of 1.0 only for neurological and developmental health endpoints. HI values for carp fillet and carp whole body also exceeded a value of 1.0. The health endpoint with the maximum HI value tended to vary by tissue type. The immunological health endpoint had the highest HI for all whole-body samples and carp fillet. Neurological and developmental health endpoints had the highest HI values for all fillet samples except carp fillet. The maximum HI values under this scenario ranged from 4.2 to 19 for fillet samples and 13 to 19 for whole-body samples. These results suggest that the exposure represented by this scenario may pose an unacceptable noncarcinogenic health risk to children of age 14 and younger.

Table 5-4a. Total noncarcinogenic hazard indices for subsistence anglers—adults with a fish ingestion rate of 142.4 g/day (19 8-oz meals/month)

	Bass	Carp		Pikeminnow		Sucker	
Endpoint	Fillet	Fillet	Whole Body	Fillet	Whole Body	Fillet	Whole Body
Metabolic[a]	0.06	0.2	0.6	0.05	0.09	0.06	0.1
Hematopoietic[b]	0.000005	nd	0.0001	0.00002	0.0001	0.00005	0.0002
Immunological[c]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	nd	[illegible]
Cardiovascular[d]	0.02	nd	0.04	nd	nd	0.03	0.1
Renal[e]	0.006	0.00003	0.04	0.0001	0.03	0.0001	0.02
Hepatic[f]	0.1	0.9	[illegible]	0.1	0.5	0.1	0.7
Neurological[g]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Intestional lesions[h]	nd	nd	0.002	0.002	0.0007	nd	0.007
Argyria[i]	nd	nd	0.008	nd	nd	0.008	0.009
Thyroid[j]	0.0004	nd	0.001	nd	0.002	nd	nd
Total HI[k]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

NOTE: HI = hazard index
nd = chemical(s) with this health endpoint were not detected
[illegible] values exceed 1.0

Chemicals contributing to hazard index were:
[a] antimony, nickel, zinc, endosulfan(I), and naphthalene
[b] fluoranthene and fluorene
[c] Aroclors
[d] total inorganic arsenic and endosulfan(I)
[e] endosulfan(I), gamma HCH, fluoranthene, pyrene, and cadmium
[f] hexachlorobenzene, heptachlor epoxide, gamma HCH, mirex, fluoranthene, acenaphthene, aldrin, dieldrin, chlordane (total), DDT (comprised of DDE, DDD, and DDT), endrin, thallium, and heptachlor
[g] mercury and endrin
[h] beryllium
[i] silver
[j] mirex
[k] The sum of HQs for all noncarcinogenic chemicals regardless of endpoint

Table 5-4b. Total noncarcinogenic hazard indices for subsistence anglers—women of childbearing age with a fish ingestion rate of 109.72 g/day (15 8-oz meals/month

	Bass	Carp		Pikeminnow		Sucker	
Endpoint	Fillet	Fillet	Whole Body	Fillet	Whole Body	Fillet	Whole Body
Reproductive/ developmental	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total HI[a]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

NOTE: HI = hazard index
Shaded values exceed 1.0
Women of reproductive age (15-44 years) and a body weight of 67 kg
Chemicals contributing to hazard index were mercury and methoxychlor

[a] The sum of HQs for all noncarcinogenic chemicals regardless of endpoint

Table 5-4c. Total noncarcinogenic hazard indices for subsistence anglers—children with a fish ingestion rate of 77.95 g/day (11 8-oz meals/month)

	BASS	CARP		PIKEMINNOW		SUCKER	
ENDPOINT	FILLET	FILLET	WHOLE BODY	FILLET	WHOLE BODY	FILLET	WHOLE BODY
Metabolic[a]	0.08	0.3	0.8	0.07	0.1	0.08	0.2
Hematopoietic[b]	0.000003	nd	0.0002	0.00003	0.0001	0.00007	0.0002
Immunological[c]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	nd	[illegible]
Cardiovascular[d]	0.03	nd	0.05	nd	nd	0.03	0.2
Renal[e]	0.007	0.00004	0.05	0.0001	0.03	0.0002	0.02
Hepatic[f]	[illegible]	[illegible]	[illegible]	0.2	0.7	0.2	0.9
Neurological[g]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Developmental[h]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Intestional lesions[i]	nd	nd	0.002	0.003	0.0009	nd	0.009
Argyria[j]	0.00002	nd	0.01	nd	nd	0.01	0.01
Thyroid[k]	0.0006	nd	0.002	nd	0.002	nd	nd
Total HI[l]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

NOTE: HI = hazard index
[illegible] values exceed 1.0
Children of 0-14 years and a body weight of 30 kg.
nd = chemical(s) with this health endpoint were not detected

Chemicals contributing to hazard index were:

- [a] antimony, nickel, zinc, endosulfan(I), and naphthalene
- [b] fluoranthene and fluorene
- [c] Aroclors
- [d] total inorganic arsenic and endosulfan(I)
- [e] endosulfan(I), gamma HCH, fluoranthene, pyrene, and cadmium
- [f] hexachlorobenzene, heptachlor epoxide, gamma HCH, mirex, fluoranthene, acenaphthene, aldrin, dieldrin, chlordane (total), DDT (comprised of DDE, DDD, and DDT), endrin, thallium, and heptachlor
- [g] mercury and endrin
- [h] mercury and methoxychlor
- [i] beryllium
- [j] silver
- [k] mirex
- [l] The sum of HQs for all noncarcinogenic chemicals regardless of endpoint

The HI values discussed above provide point estimates for ingestion rates selected to be representative of three possible target populations. Figures 5-1 through 5-4 graphically show adult HI estimates, and Figures 5-5 through 5-8 graphically show child HI estimates for each noncarcinogenic health endpoint over a range of consumption rates from 0.6 g/day to 540 g/day. Assuming a typical meal size of 8 ounces, 0.6 g/day corresponds to a consumption rate of one meal per year. The upper value, 540 g/day, is the maximum suggested fish consumption rate for Native Americans within the Columbia River basin (Harris and Harper 1997). This range of consumption rates allows the reader to identify cancer risks associated with personal consumption patterns.

Chemicals of Potential Concern for Noncarcinogenic Health Endpoints

Noncarcinogenic health endpoints with HI values exceeding 1.0 under the recreational or subsistence angler scenarios included immunological, neurological, reproductive/developmental, and hepatic. Table 5-5 shows the percent contribution of individual chemicals to the HI values for noncarcinogenic health endpoints. The immunological

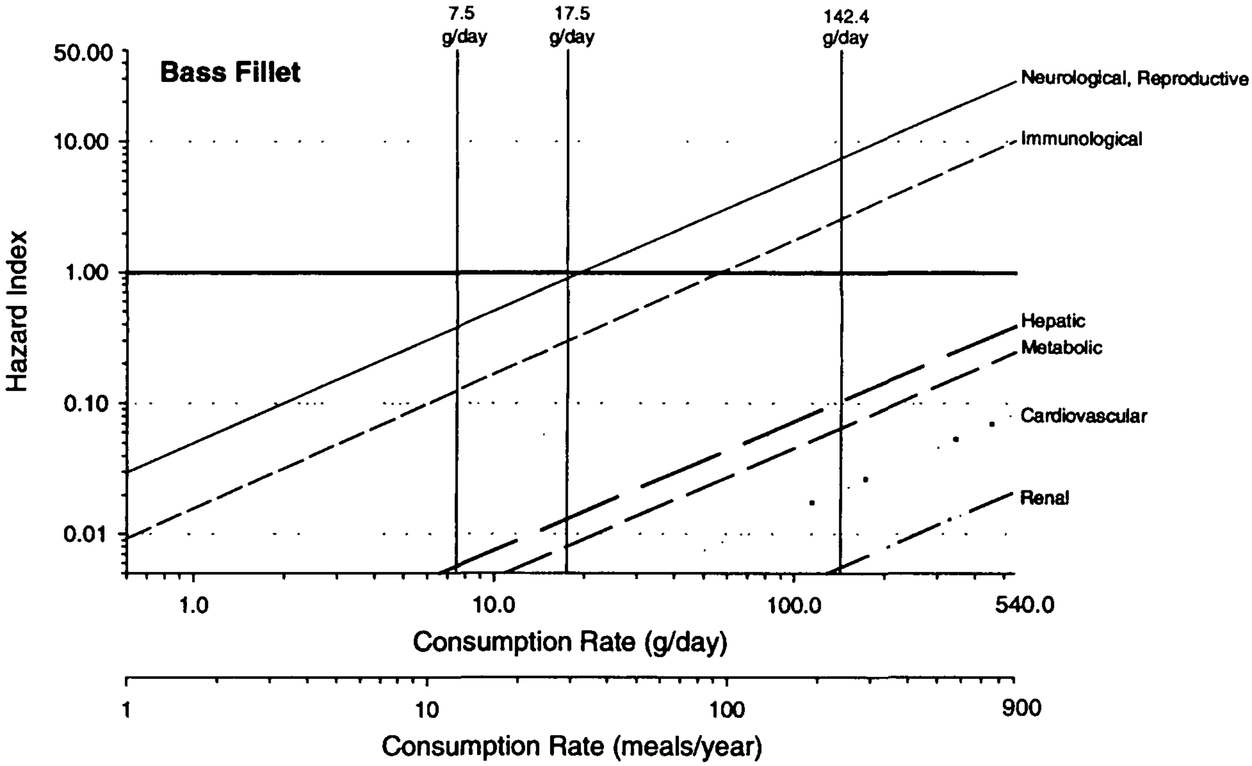
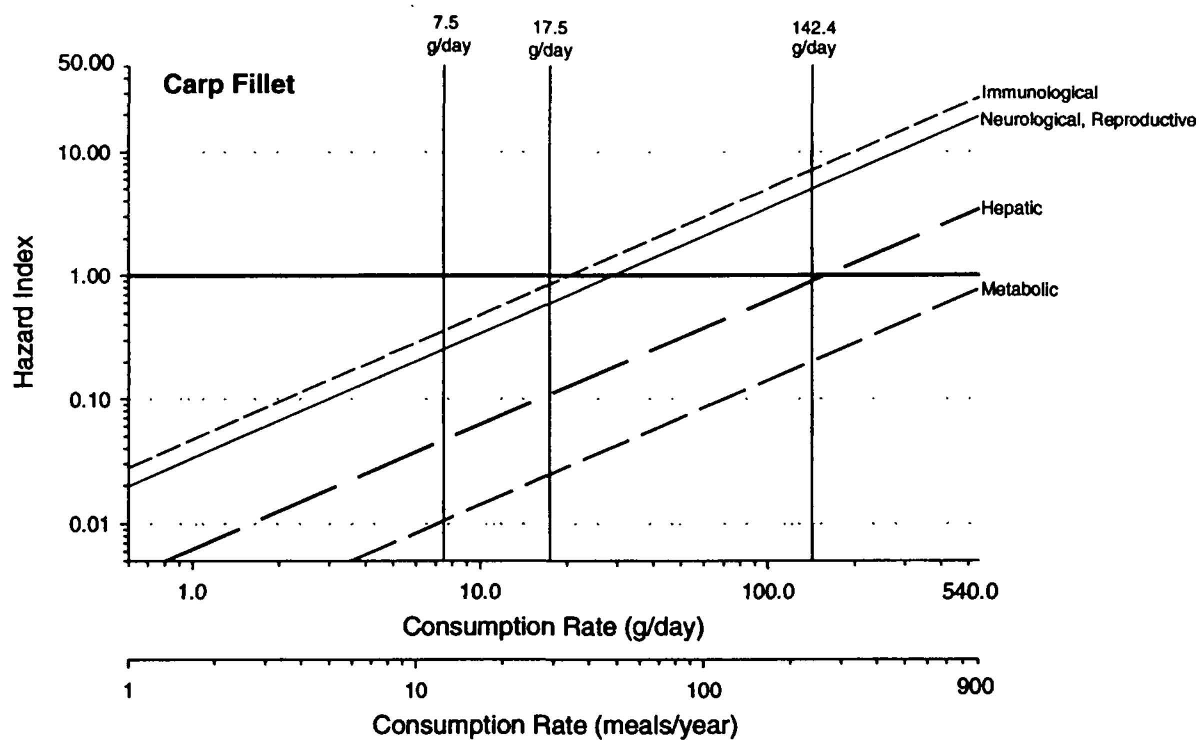


Figure 5-1. Estimated adult hazard indices for consuming bass fillet



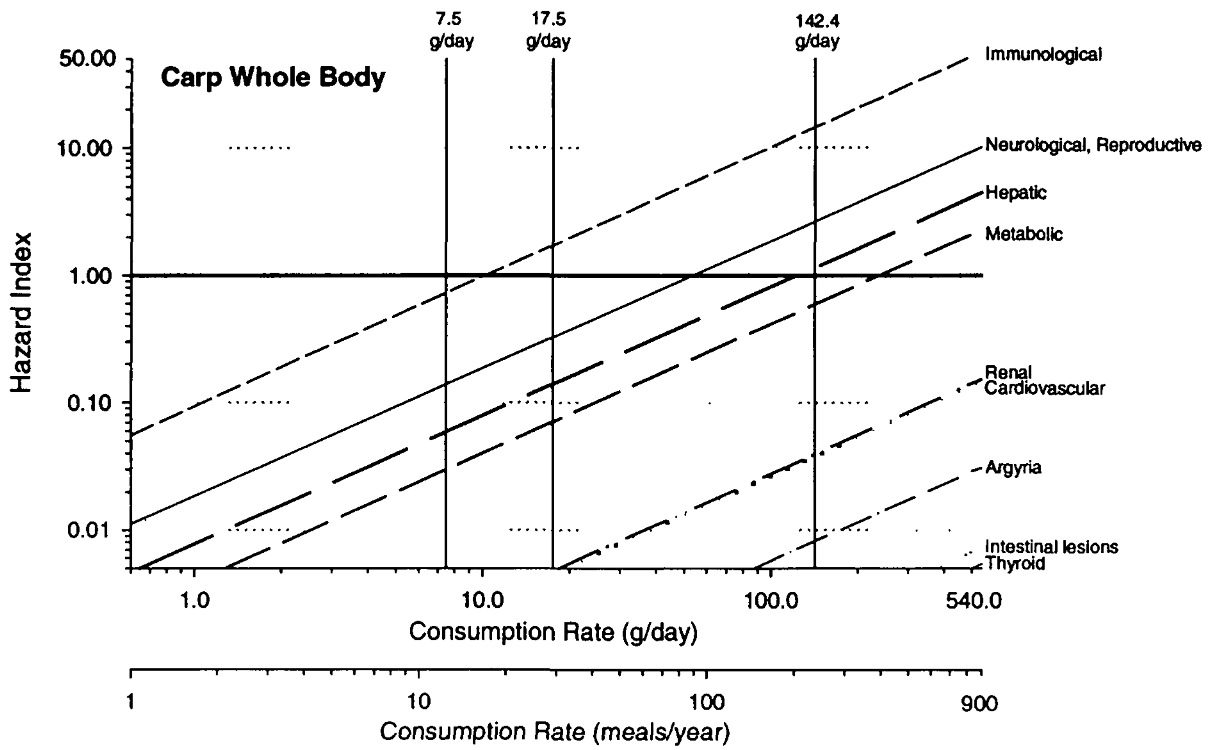
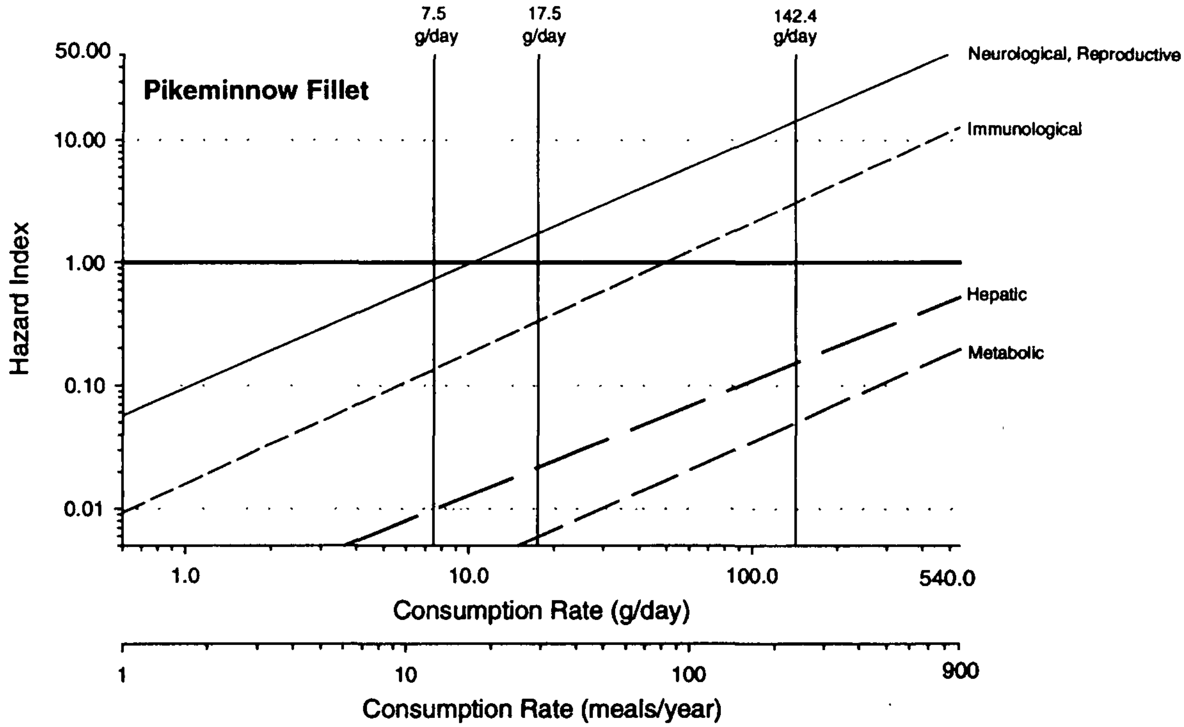


Figure 5-2. Estimated adult hazard indices for consuming carp fillet and carp whole body



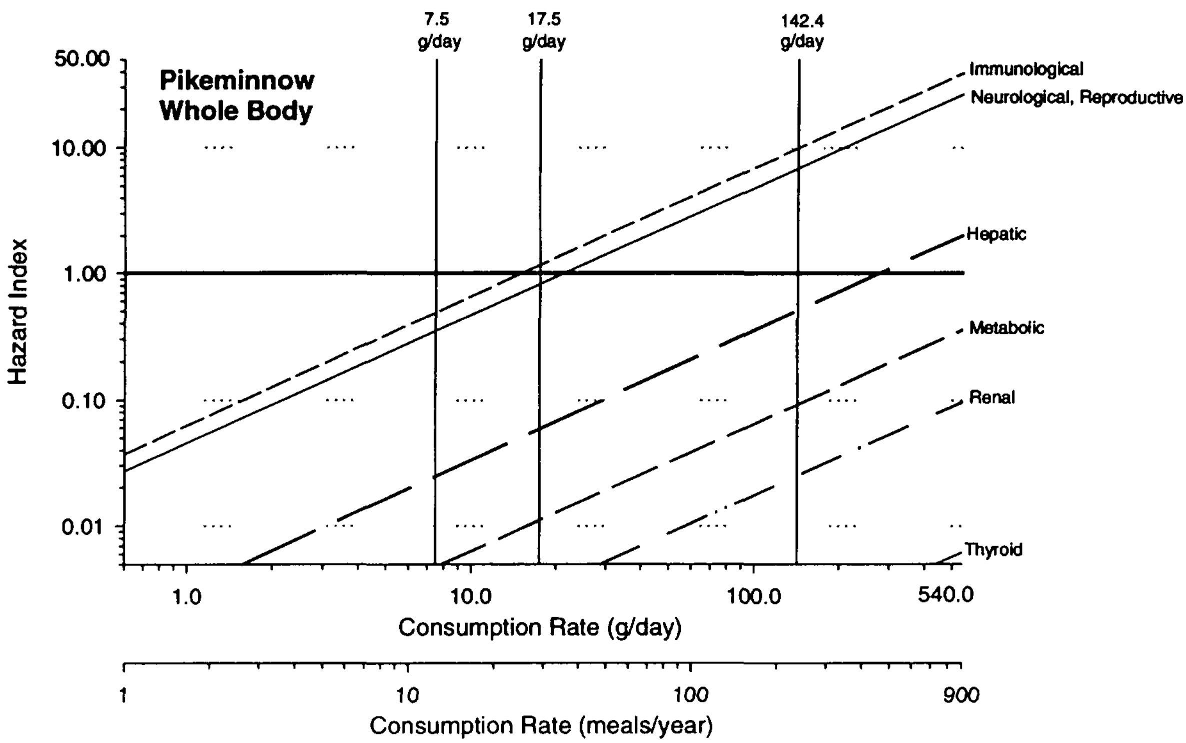


Figure 5-3. Estimated adult hazard indices for consuming pikeminnow fillet and pikeminnow whole body

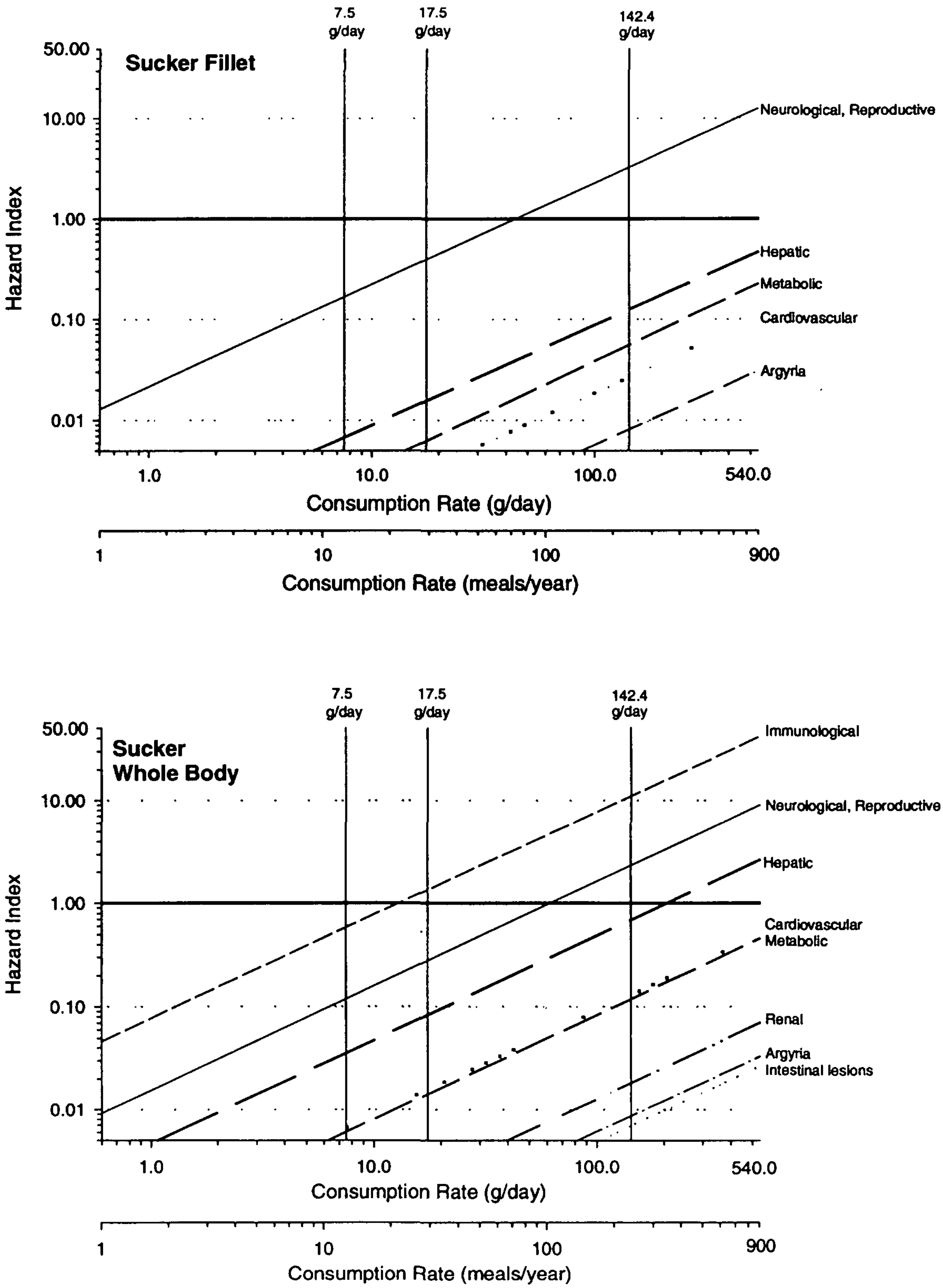


Figure 5-4. Estimated adult hazard indices for consuming sucker fillet and sucker whole body

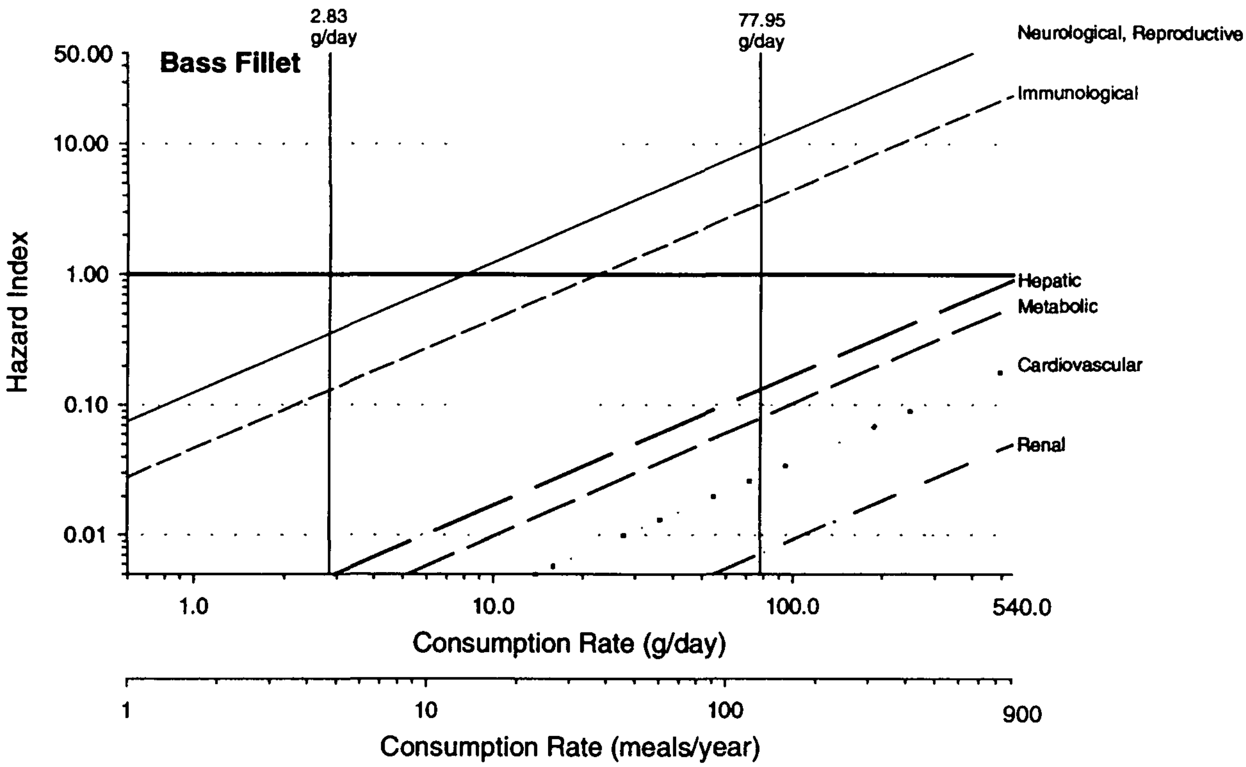


Figure 5-5. Estimated child hazard indices for consuming bass fillet

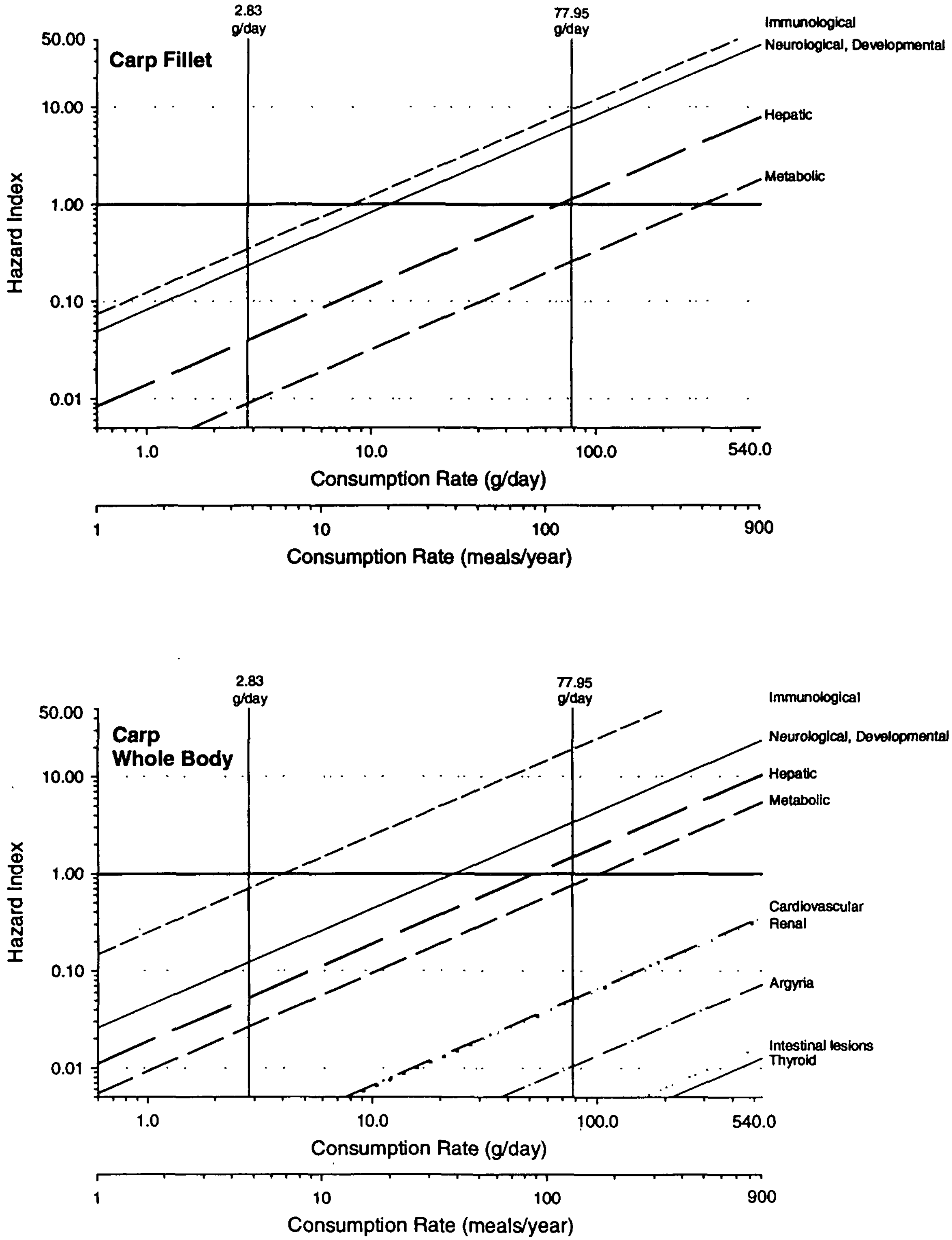
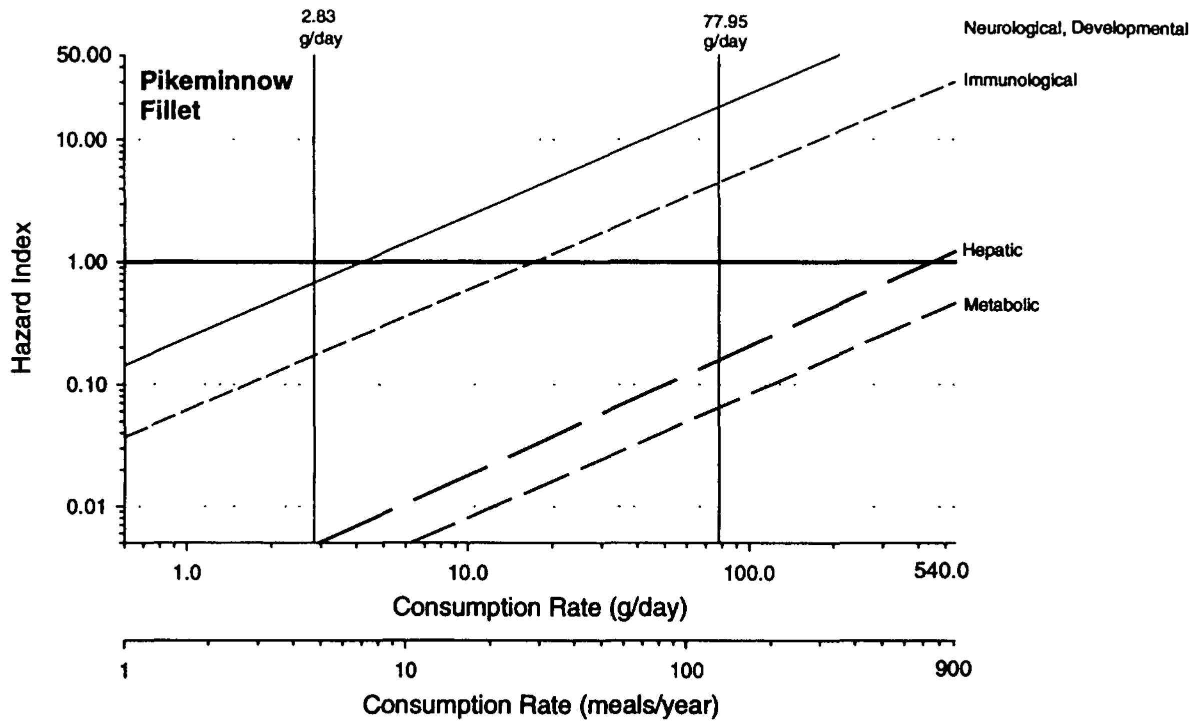


Figure 5-6. Estimated child hazard indices for consuming carp fillet and carp whole body



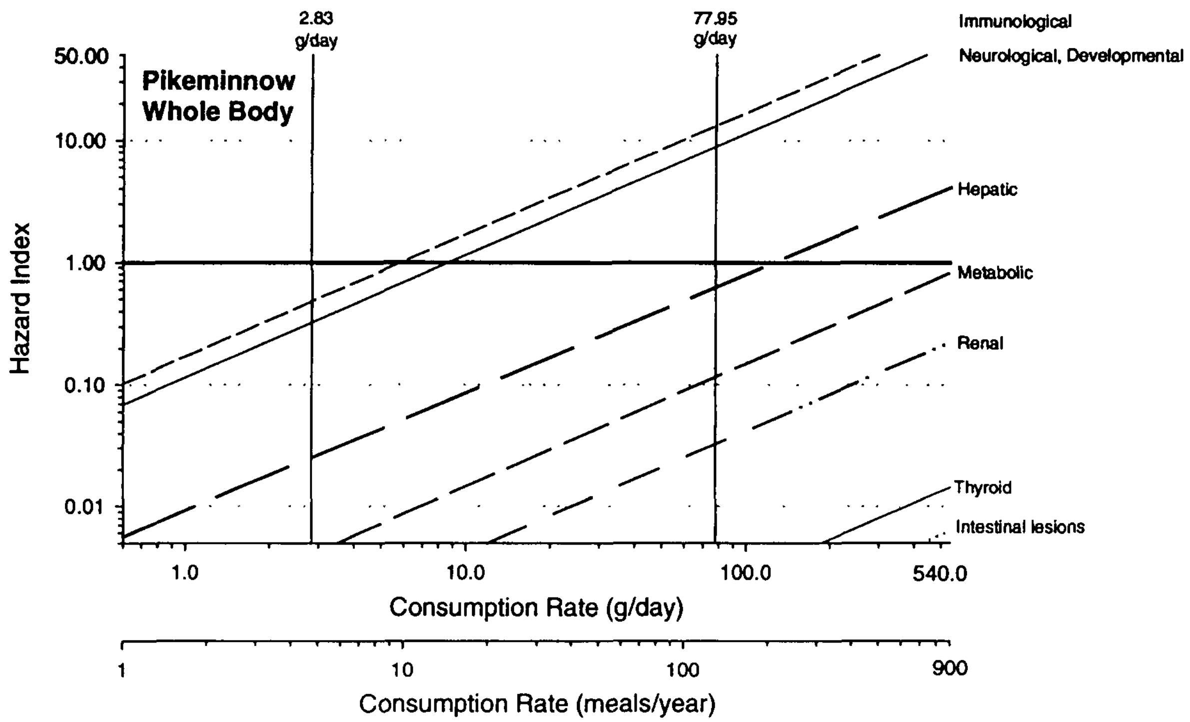
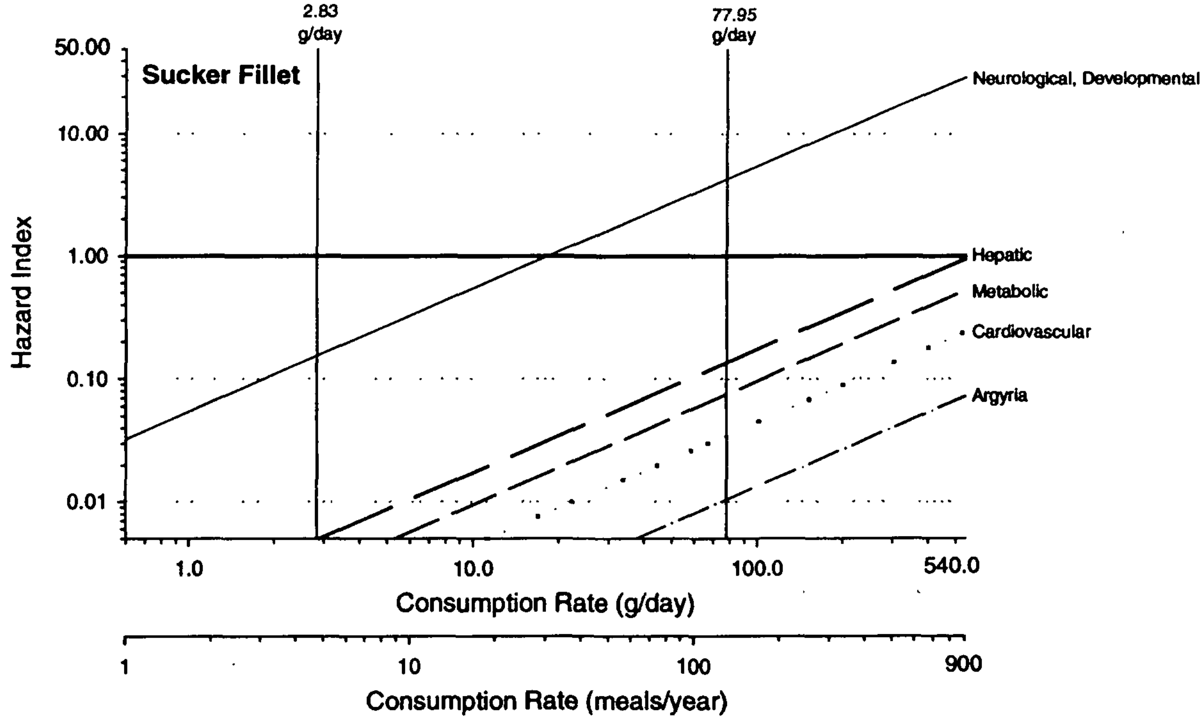


Figure 5-7. Estimated child hazard indices for consuming pikeminnow fillet and pikeminnow whole body



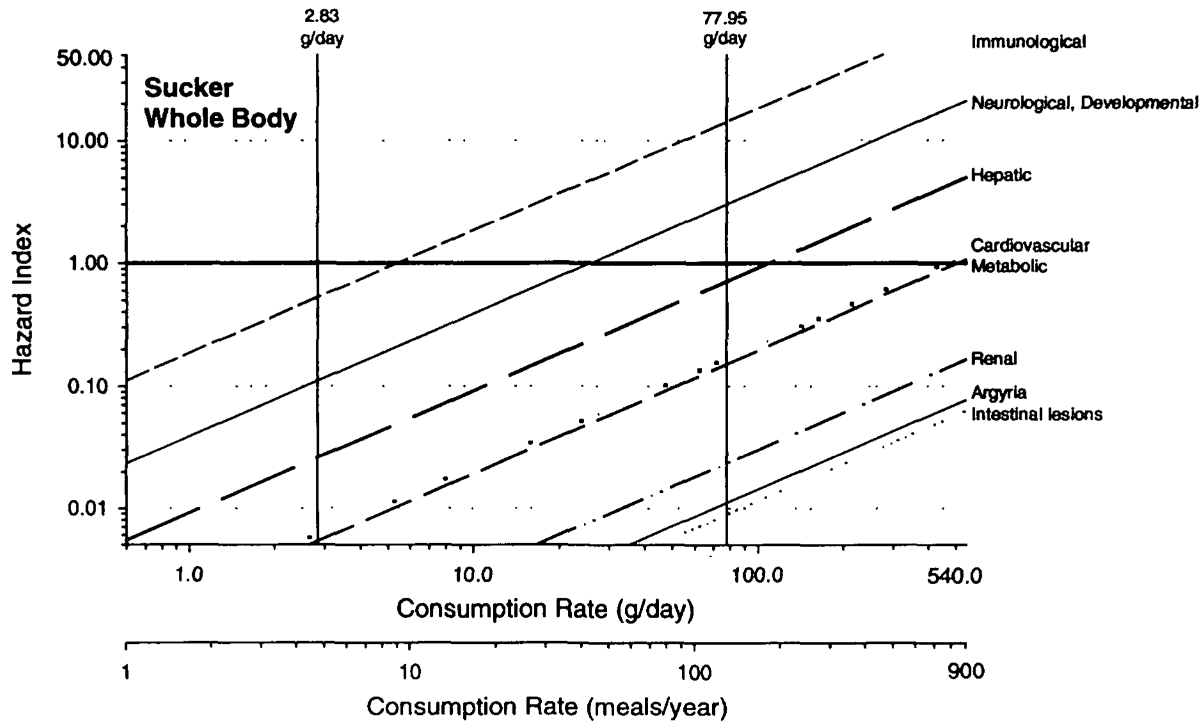


Figure 5-8. Estimated child hazard indices for consuming sucker fillet and sucker whole body

Table 5-5. Percent contribution of contaminant groups and individual chemicals with toxicity values to endpoint-specific hazard indices

Hazard Index/ Contaminant Group/Chemical		Bass	Carp		Pikeminnow		Sucker	
		Fillet	Fillet	Whole Body	Fillet	Whole Body	Fillet	Whole Body
Neurological Hazard Index								
Metals	Mercury	100	100	100	100	100	100	100
Pesticides	Endrin	0	0	0.00005	0	0	0	0
Hepatic Hazard Index								
Pesticides	Chlordane (total)	7	4	7	8	9	0	9
	Total DDT [a]	76	84	74	75	73	82	63
	Dieldrin	9	8	13	15	13	14	20
	Hexachlorobenzene	2	0.7	1	2	1	0	1
	Heptachlor epoxide	0	3	4	0	3	4	6
	gamma HCH	5	0	0.5	0	0	0	0
	Mirex	0.4	0	0.1	0	0.3	0	0
Pesticides/PAHs	Other chemicals [b]	0.04	0	0.01	0.02	0.02	0.03	0.03
Renal Hazard Index								
Metals	Cadmium	0	0	85	0	100	0	99
PAHs	Fluoranthene	0.4	0	0.2	24	0.1	15	0.3
	Pyrene	0.3	100	0.3	76	0.1	85	0.4
Pesticides	alpha-Endosulfan (I)	0	0	0.2	0	0	0	0
	gamma HCH	99	0	14	0	0	0	0
Reproductive/Developmental Hazard Index								
Metals	Mercury	100	100	100	100	100	100	100
Pesticides	Methoxychlor	0	0	0.003	0	0	0	0
Cardiovascular Hazard Index								
Metals	Total inorganic arsenic	100	0	100	0	0	100	100
Pesticides	alpha-Endosulfan (I)	0	0	0.2	0	0	0	0
Immunological Hazard Index								
PCBs	Aroclors	100	100	100	100	100	100	100
Metabolic Hazard Index								
Metals	Antimony	0	0	0.6	0	0	0	3
	Nickel	18	0	2	8	1	4	26
	Zinc	80	99	97	90	98	96	71
PAHs	Naphthalene	2	0.6	0.2	0.2	2	0.5	0.6
Pesticides	alpha-Endosulfan (I)	0	0	0.01	0	0	0	0
Hematopoietic Hazard Index								
PAHs	Fluoranthene	100	0	52	100	25	45	31
	Fluorene	0	0	48	0	75	55	69

[a] Based on the sum of DDT, DDD, DDE
[b] Includes endrin, fluoranthene, and acenaphthene

health endpoint is comprised of HQ values only for Aroclors. The HI for neurological and reproductive/developmental health endpoints includes HQ values for mercury and two pesticides. However, the percent contribution of mercury to the HI for both of these endpoints is 100 percent. The HI for the hepatic health endpoint includes HQ values for several pesticides and PAHs. Total DDT and dieldrin comprised the greatest percentage of the total HI for the hepatic health endpoint. The percent contribution for DDT in different tissue types ranged from 63 to 84 percent of the total HI value; the percent contribution of dieldrin to the HI value ranged from 8 to 20 percent.

Thirty chemicals were analyzed in fish tissue that have chronic RfD values for assessing noncarcinogenic health endpoints. Mercury, total Aroclors, and total DDT (sum of total DDD, DDE, and DDT) had HQ values that exceeded a value of 1.0 for at least one fish species for either the recreational angler or subsistence angler exposure scenarios (Table 5-6). No chemical had an HQ value greater than 1.0 for the general public fish consumption scenario.

Table 5-6. Chemicals exceeding hazard quotient of 1.0 for various consumption rates

Chemical	Ingestion Rate (g/day)	Bass	Carp		Pikeminnow		Sucker	
		Fillet	Fillet	Whole Body	Fillet	Whole Body	Fillet	Whole Body
Adults:								
Mercury	17.5	–	–	–	1.8	–	–	–
	142.4	7.6	5.0	2.7	14	7.0	3.3	2.4
Total Aroclors [a]	17.5	–	–	1.8	–	1.3	–	1.3
	142.4	2.7	7.2	15	3.4	10	–	11
Women:								
Mercury	109.72	6.1	4	2.1	12	5.6	2.7	1.9
Total Aroclors [a]	109.72	2.1	5.8	12	2.7	8.3	–	8.8
Children:								
Mercury	77.95	9.7	6.4	3.4	18	8.9	4.2	3
Total Aroclors [a]	77.95	3.4	9.2	19	4.3	13	–	14
Total DDT [b]	77.95	–	–	1.1	–	–	–	–

NOTE: – indicates HQ did not exceed 1.0 or chemical was not detected

[a] Based on the sum of Aroclors 1242, 1254, 1260.
[b] Based on the sum of total DDD, DDE, DDT.

Recreational Anglers

Mercury and total Aroclors had HQ values that exceeded 1.0 for the recreational angler scenario for adults. The HQ values for total Aroclors in whole-body tissue of carp, pikeminnow, and sucker exceeded 1.0; values ranged from 1.3 to 1.8 (Table 5-6). The HQ values for mercury under this exposure scenario exceeded 1.0 only for pikeminnow fillet, which had a value of 1.8. No chemical had an HQ values greater than 1.0 for women of childbearing age under the recreational angler scenario.

Subsistence Anglers

All fish species and sample types had HQ values for mercury that exceeded 1.0 for adults, women, and children under the subsistence angler scenario (Table 5-6). HQ values for adults ranged from 2.4 to 14; values for women ranged from 2.1 to 12, and values for children ranged from 3.0 to 18. Mercury HQ values for consuming fillet tissue were on average 1.8 times higher than for consuming whole-body tissue. The ratio of the fillet HQ value to the whole-body HQ value for carp, pikeminnow, and sucker was 1.9, 2.0, and 1.4, respectively.

All fish species and sample types except sucker fillet also had HQ values for total Aroclors that exceeded 1.0 for adults, women, and children under the subsistence angler scenario (Table 5-6). Aroclors were not detected in sucker fillet tissue. HQ values for adults ranged from 2.7 to 15; values for women ranged from 2.1 to 12, and values for children ranged from 3.4 to 19. For carp and pikeminnow, total Aroclor HQ values were on average 2.5 times higher for whole-body tissue than for fillet tissue. The ratio of the whole-body HQ value to the fillet HQ value was 2.1 for carp and 2.9 for pikeminnow.

The HQ value for total DDT exceeded 1.0 only for carp whole-body tissue under the children subsistence angler scenario. The HQ value for this tissue type was 1.1 (Table 5-6).

5.2.3 Carcinogenic Risk Estimates

Table 5-7 shows total excess carcinogenic risk estimates for the three target populations for both a 30-year and 70-year exposure duration. Risk estimates for all four fish species, tissue types, and all target populations exceed an acceptable risk threshold of 1.0E-06. The risk estimates for different fish and sample types for the three target populations exceeded an ARL of 1.0E-06 by factors ranging from 4 to 3,000 (Table 5-8). The exposure assumptions for the three target populations differed only for the ingestion rate parameter. Thus, the risk estimates for the target populations differ by the ratio of the default ingestion rates. Risk estimates for recreational anglers were higher by a factor of 2.3 than estimates for the general population. Risk estimates for subsistence anglers were higher by a factor of 19 than estimates for the general population.

Table 5-7a. Total excess carcinogenic risk estimates for the general population

General Population Ingestion Rate	Bass Fillet	Carp Fillet	Carp Whole Body	Pikeminnow Fillet	Pikeminnow Whole Body	Sucker Fillet	Sucker Whole Body
7.5 g/day (12 8-oz meals/year)							
30-Year Exposure	9.9E-06	3.2E-05	6.7E-05	2.1E-05	5.1E-05	4.0E-06	4.5E-05
70-Year Exposure	2.3E-05	7.5E-05	1.6E-04	4.9E-05	1.2E-04	9.4E-06	1.0E-04

Table 5-7b. Total excess carcinogenic risk estimates for recreational anglers

Recreational Angler Ingestion Rate	Bass Fillet	Carp Fillet	Carp Whole Body	Pikeminnow Fillet	Pikeminnow Whole Body	Sucker Fillet	Sucker Whole Body
17.5 g/day (28 8-oz meals/year)							
30-Year Exposure	2.3E-05	7.5E-05	1.6E-04	4.9E-05	1.2E-04	9.4E-06	1.0E-04
70-Year Exposure	5.4E-05	1.7E-04	3.6E-04	1.1E-04	2.8E-04	2.2E-05	2.4E-04

Table 5-7c. Total excess carcinogenic risk estimates for subsistence anglers

Subsistence Angler Ingestion Rate	Bass Fillet	Carp Fillet	Carp Whole Body	Pikeminnow Fillet	Pikeminnow Whole Body	Sucker Fillet	Sucker Whole Body
142.4 g/day (19 8-oz meals/month)							
30-Year Exposure	1.9E-04	6.1E-04	1.3E-03	4.0E-04	9.6E-04	7.7E-05	8.5E-04
70-Year Exposure	4.4E-04	1.4E-03	3.0E-03	9.3E-04	2.2E-03	1.8E-04	2.0E-03

Table 5-8. Range of values for the ratio cancer risk:ARL for target populations

Exposure Duration	General Population	Recreational Angler	Subsistence Angler
30-year	9–160	4–67	77–1,300
70-year	9–160	22–360	180–3,000

NOTE: ARL = acceptable risk level

The risk estimates presented in this report are based on fillets with skin and whole-body tissue. These sample types were selected to characterize risk for what is likely the most commonly consumed portion of the fish (fillet) and to provide an estimate of the risk of consuming a larger proportion of the fish (whole-body). The ratio between excess cancer risk estimates for whole-body and fillet samples was 2.1 for carp, 2.4 for pikeminnow, and 11.1 for sucker, showing that overall cancer risk may be higher for individuals who consume the entire fish.

Cancer risk estimates for fillet tissue were lowest for sucker and increased in ascending order for bass, pikeminnow, and carp. Table 5-9 compares the excess cancer risk of bass, pikeminnow, and carp relative to sucker, which had the lowest excess cancer risk. This shows that the cancer risk of consuming carp fillet is 8 times as high as the risk of consuming sucker fillet.

Table 5-9. Comparison of the relative risk of consuming fillet and whole-body tissue for the different fish species

Species	Relative Fillet Cancer Risk[a]	Relative Whole Body Cancer Risk[b]
Sucker	1.0	1.0
Bass	2.5	na
Pikeminnow	5.3	1.1
Carp	8.0	1.5

NOTE: na = not available

[a] Calculated as (species fillet risk)/(sucker fillet risk).
[b] Calculated as (species whole body risk)/(sucker whole body risk).

Risk estimates for whole-body tissue were also lowest for sucker and increased in ascending order for pikeminnow, and carp. The range of risk estimates for the whole-body tissue among species was smaller (1.5) than for fillet tissue (Table 5-9).

The excess cancer risk estimates discussed above provide point estimates for ingestion rates selected to be representative of three possible target populations. Figures 5-9 through 5-12 graphically show excess cancer risk estimates over a range of consumption rates from 0.6 g/day to 540 g/day. Assuming a typical meal size of 8 ounces, 0.6 g/day corresponds to a consumption rate of one meal per year. The upper value, 540 g/day, is the maximum suggested fish consumption rate for Native Americans within the Columbia River basin (Harris and Harper 1997). This range of consumption rates allows the reader to identify cancer risks associated with personal consumption patterns.

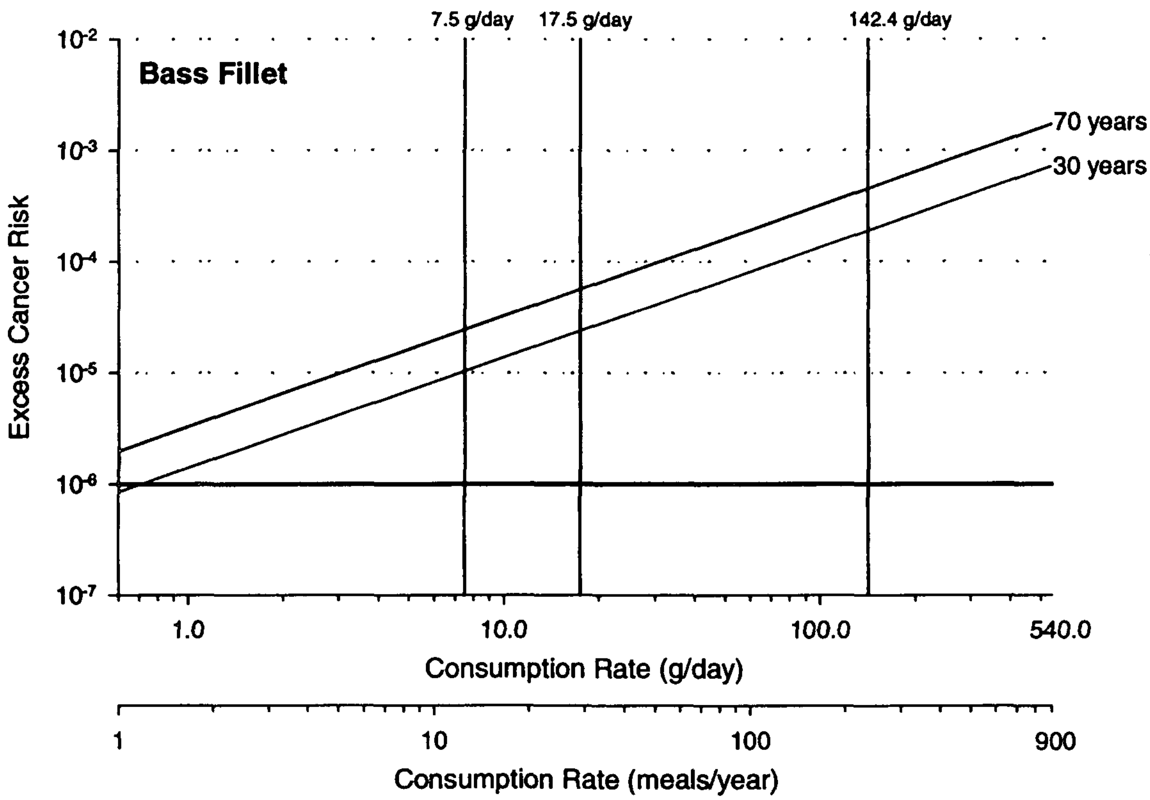
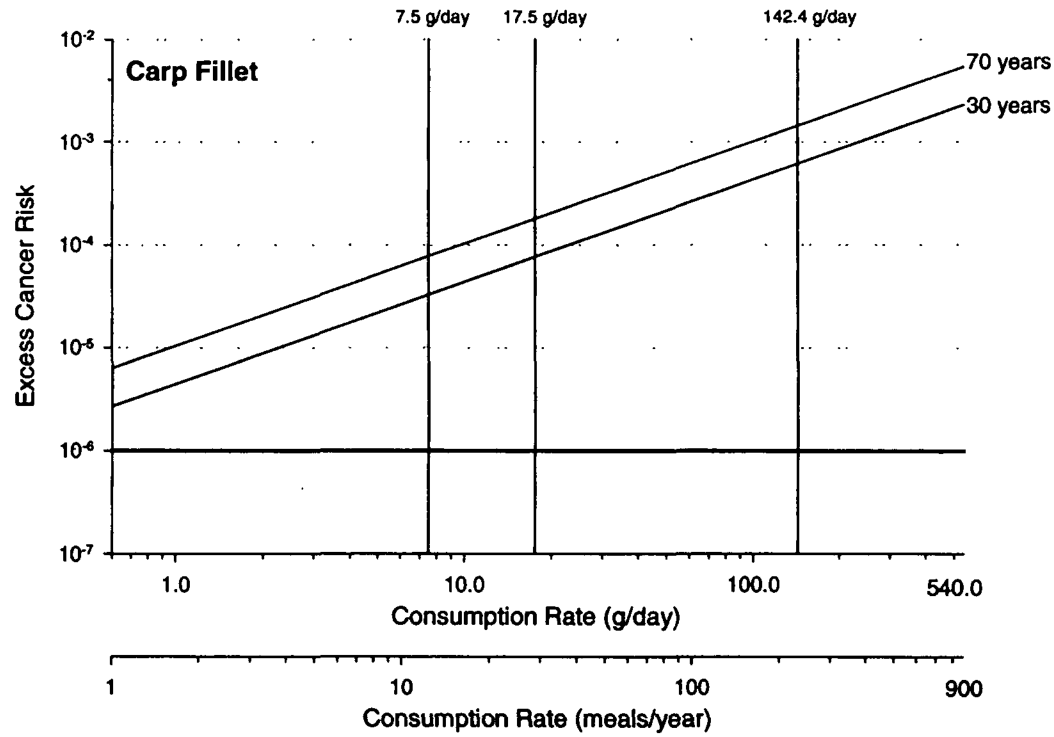


Figure 5-9. Estimated excess cancer risk for consuming bass fillet



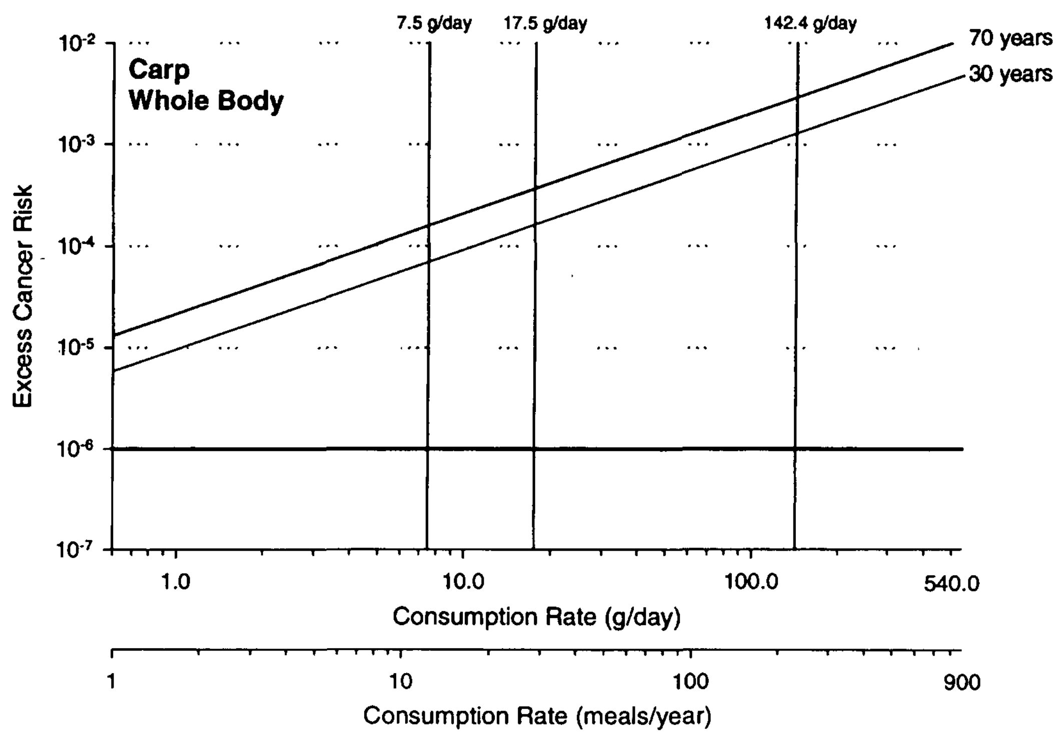


Figure 5-10. Estimated excess cancer risk for consuming carp fillet and carp whole body

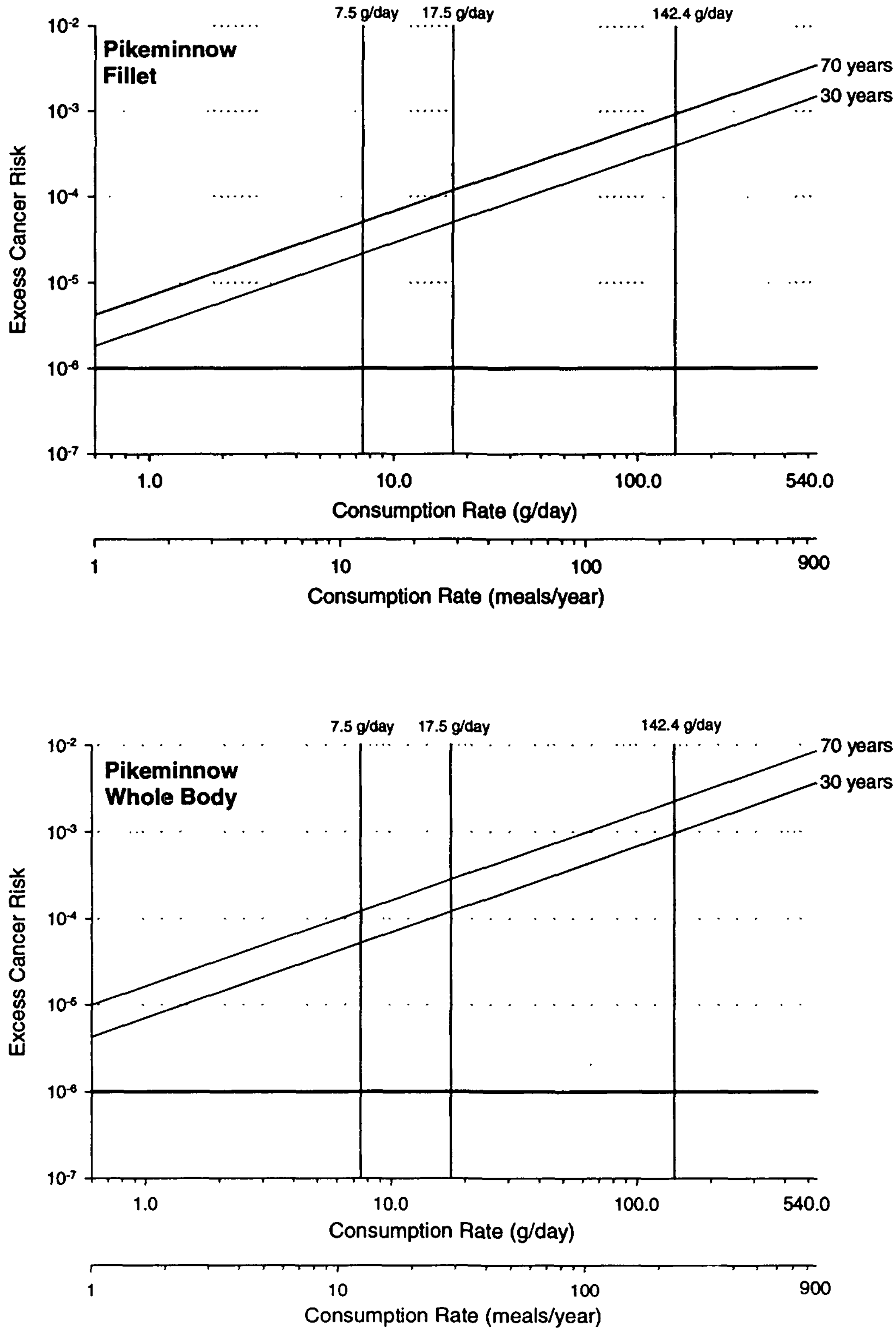
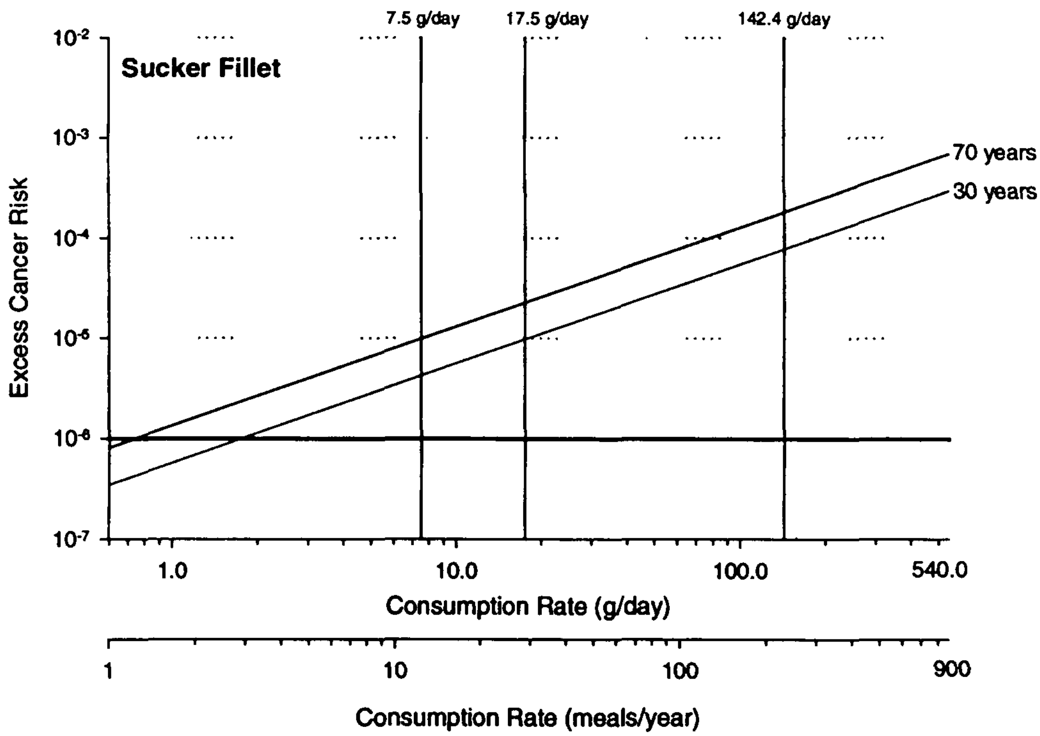


Figure 5-11. Estimated excess cancer risk for consuming pikeminnow fillet and pikeminnow whole body



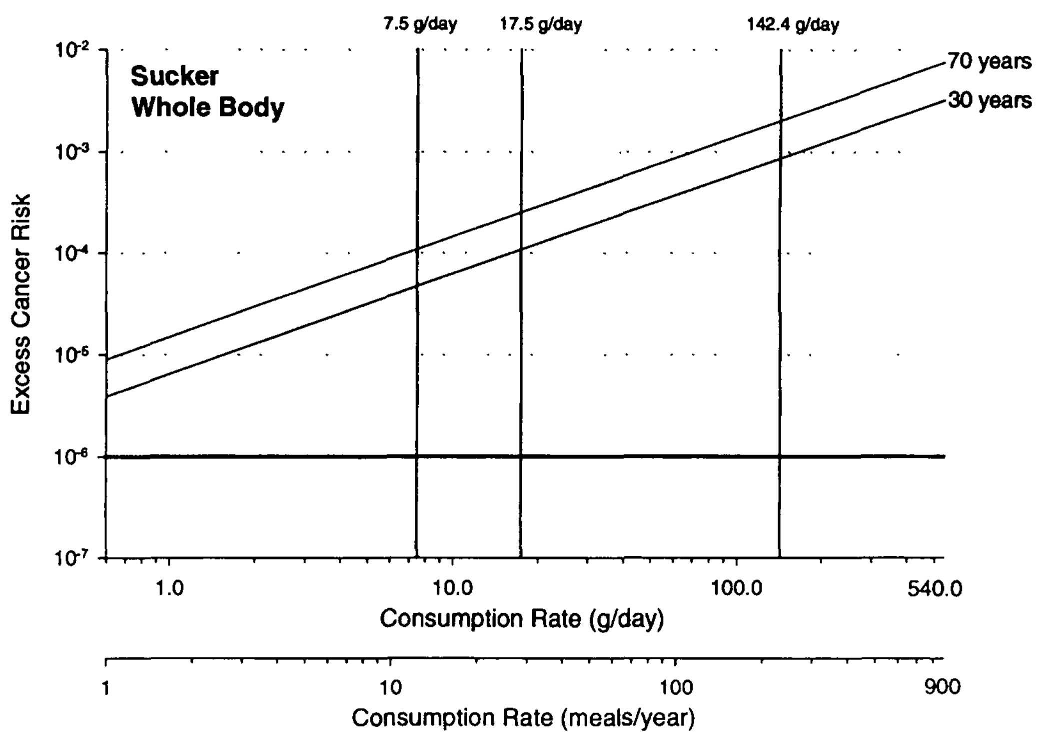


Figure 5-12. Estimated excess cancer risk for consuming sucker fillet and sucker whole body

Chemicals of Potential Concern for a Health Endpoint of Cancer

Fifty-one chemicals were analyzed in fish tissue that have SFs for assessing the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen. Forty of these chemicals, 78 percent of the carcinogenic chemicals evaluated, had an excess cancer risk estimate that exceeded an ARL of 1.0E-06 for at least one of the target populations under the exposure assumptions used for this risk assessment. Table 5-10 identifies the chemicals that have an excess cancer risk estimate that exceeded an ARL of 1.0E-06 for an exposure duration of 30 years; Table 5-11 shows chemicals that exceeded the ARL for an exposure duration of 70 years.

General Population

A total of 14 chemicals exceeded an ARL of 1.0E-06 for the general population scenario which assumed a 30-year exposure duration and a fish consumption rate of 7.5 grams per day (Table 5-10). These chemicals were from all chemical groups analyzed except PAHs. The number of chemicals that exceeded the ARL varied among tissue type and fish species. Whole body tissue had a higher number of chemicals exceeding the ARL than fillet tissue. For fillet tissue the number of chemicals with excess cancer risk estimates exceeding the ARL was lowest in sucker (1) followed in increasing order by bass (3), pikeminnow (6), and carp (9). Two chemicals—PCB 126 in whole-body carp and whole-body pikeminnow and Aroclors in whole-body carp—had excess cancer risk estimates that exceeded 1.0E-05; risk estimates for all other chemicals were less than this risk probability. The highest chemical–specific excess cancer risk estimate under this scenario was 1.4E-05 for PCB 126 in pikeminnow whole-body tissue.

A total of 17 chemicals exceeded an ARL of 1.0E-06 for the general population exposure scenario with a 70-year exposure duration and a fish consumption rate of 7.5 grams per day (Table 5-11). These chemicals were from all chemical groups analyzed except PAHs. The number of chemicals that exceeded the ARL varied among tissue type and fish species. Whole body tissue had a higher number of chemicals exceeding the ARL than fillet tissue. For fillet tissue the number of chemicals with excess cancer risk estimates exceeding the ARL was lowest in sucker (4) followed in increasing order by bass (6), pikeminnow (10), and carp (12). Six chemicals—aldrin, PCB 118, PCB 126, Aroclors, 2,3,7,8-TCDD, and 1,2,3,7,8-PeCDD—had an excess cancer risk estimate in at least one fish species and tissue type that exceeded 1.0E-05. The highest chemical–specific excess cancer risk estimate under this scenario was 3.2E-05 for PCB 126 in pikeminnow whole-body tissue.

Table 5-10. Chemicals exceeding excess cancer risk of 1.0E-6 for various consumption rates and exposure duration of 30 years

	Excess Cancer Risk by Consumption Rate (g/day)								
	Bass Fillet			Carp Fillet			Carp Whole Body		
	7.5[a]	17.5[b]	142.4[c]	7.5[a]	17.5[b]	142.4[c]	7.5[a]	17.5[b]	142.4[c]
Metals									
Total inorganic arsenic			4.3E-06						7.4E-06
PAHs									
Benz(bjk)fluoranthenes									1.1E-06
Benzo(a)pyrene								1.0E-06	8.3E-06
Pesticides									
Aldrin						1.2E-06	1.0E-06	2.3E-06	1.9E-05
alpha-HCH									
Chlordane (total)						2.9E-06			6.4E-06
DDD total						2.2E-06			3.9E-06
DDE total			4.8E-06	2.7E-06	6.2E-06	5.0E-05	2.9E-06	6.9E-06	5.6E-05
DDT total									1.2E-06
Dieldrin			3.3E-06	1.3E-06	3.1E-06	2.5E-05	2.7E-06	6.3E-06	5.2E-05
gamma-HCH						1.0E-06			1.3E-06
Heptachlor epoxide						1.3E-06			2.4E-06
Hexachlorobenzene			1.1E-06			3.6E-06			7.2E-06
PCBs									
PCB 77									1.0E-06
PCB 105			6.2E-06		1.7E-06	1.4E-05	1.5E-06	3.5E-06	2.8E-05
PCB 114						6.4E-06		1.5E-06	1.3E-05
PCB 118	1.1E-06	2.5E-06	2.0E-05	2.8E-06	6.5E-06	5.3E-05	5.7E-06	1.3E-05	1.1E-04
PCB 123						2.0E-06			3.1E-06
PCB 126	2.2E-06	5.2E-06	4.2E-05	6.5E-06	1.5E-05	1.2E-04	1.1E-05	2.6E-05	2.1E-04
PCB 156/157		2.0E-06	1.6E-05	2.2E-06	5.1E-06	4.2E-05	4.2E-06	9.8E-06	8.0E-05
PCB 169			5.3E-06		1.9E-06	1.5E-05	1.7E-06	3.9E-06	3.2E-05
PCB 189									1.5E-06
Adjusted Aroclors	2.2E-06	5.1E-06	4.2E-05	6.0E-06	1.4E-05	1.1E-04	1.2E-05	2.9E-05	2.3E-04
Dioxins/Furans									
2,3,7,8-TCDD		2.1E-06	1.7E-05	2.8E-06	6.5E-06	5.3E-05	6.0E-06	1.4E-05	1.1E-04
1,2,3,7,8-PeCDD		1.8E-06	1.5E-05	3.1E-06	7.2E-06	5.9E-05	7.8E-06	1.8E-05	1.5E-04
1,2,3,4,7,8-HxCDD						4.3E-06		1.2E-06	1.0E-05
1,2,3,6,7,8-HxCDD					2.0E-06	1.6E-05	2.2E-06	5.1E-06	4.2E-05
1,2,3,7,8,9-HxCDD						1.4E-06			4.8E-06
1,2,3,4,6,7,8-HpCDD						2.9E-06			7.8E-06
2,3,7,8-TCDF			6.2E-06			5.6E-06		1.6E-06	1.3E-05
1,2,3,7,8-PeCDF									1.5E-06
2,3,4,7,8-PeCDF			3.9E-06	1.0E-06	2.4E-06	2.0E-05	2.3E-06	5.4E-06	4.4E-05
1,2,3,4,7,8-HxCDF						2.1E-06			5.2E-06
1,2,3,6,7,8-HxCDF									3.6E-06
2,3,4,6,7,8-HxCDF									2.6E-06
Total Number	3	6	14	9	12	25	13	17	34

Table 5-10, continued

	Excess Cancer Risk by Consumption Rate (g/day)											
	Pikeminnow Fillet			Pikeminnow Whole Body			Sucker Fillet			Sucker Whole Body		
	7.5[a]	17.5[b]	142.4[c]	7.5[a]	17.5[b]	142.4[c]	7.5[a]	17.5[b]	142.4[c]	7.5[a]	17.5[b]	142.4[c]
Metals												
Total inorganic arsenic									5.2E-06	1.3E-06	3.1E-06	2.5E-05
PAHs												
Dibenz(ah)anthracene						1.7E-06						
Pesticides												
Aldrin	5.1E-06	1.2E-05	9.6E-05	1.1E-06	2.5E-06	2.1E-05					2.0E-06	1.6E-05
alpha-HCH						1.1E-06						8.0E-06
Chlordane (total)						3.6E-06						4.7E-06
DDD total						1.6E-06						3.2E-06
DDE total			6.6E-06	1.3E-06	3.1E-06	2.6E-05			6.2E-06	1.2E-06	2.8E-06	2.3E-05
DDT total												4.8E-06
Dieldrin			7.3E-06	1.2E-06	2.8E-06	2.3E-05			5.9E-06	2.5E-06	5.8E-06	4.8E-05
gamma-HCH			1.2E-06			1.1E-06						1.8E-06
Heptachlor epoxide												2.2E-06
Hexachlorobenzene			1.4E-06			4.0E-06						5.4E-06
PCBs												
PCB 77						1.3E-06						
PCB 105		1.3E-06	1.0E-05	1.5E-06	3.5E-06	2.9E-05			5.0E-06	1.2E-06	2.8E-06	2.3E-05
PCB 114			5.0E-06		1.6E-06	1.3E-05			2.2E-06		1.0E-06	8.5E-06
PCB 118	1.8E-06	4.3E-06	3.5E-05	5.5E-06	1.3E-05	1.0E-04		2.1E-06	1.7E-05	3.7E-06	8.7E-06	7.1E-05
PCB 123						2.4E-06						2.7E-06
PCB 126	4.9E-06	1.1E-05	9.3E-05	1.4E-05	3.2E-05	2.6E-04				9.6E-06	2.2E-05	1.8E-04
PCB 156/157	1.5E-06	3.4E-06	2.8E-05	4.2E-06	9.8E-06	8.0E-05	1.5E-06	1.5E-06	1.2E-05	2.8E-06	6.5E-06	5.3E-05
PCB 169		1.0E-06	8.5E-06	1.5E-06	3.4E-06	2.8E-05			4.5E-06	1.2E-06	2.7E-06	2.2E-05
PCB 189						1.1E-06						
Adjusted Aroclors	2.7E-06	6.2E-06	5.1E-05	8.2E-06	1.9E-05	1.6E-04				9.2E-06	2.1E-05	1.7E-04
Dioxins/Furans												
2,3,7,8-TCDD		2.2E-06	1.8E-05	2.7E-06	6.4E-06	5.2E-05		1.4E-06	1.1E-05	2.6E-06	6.0E-06	4.9E-05
1,2,3,7,8-PeCDD	1.3E-06	3.1E-06	2.5E-05	4.1E-06	9.7E-06	7.9E-05		1.0E-06	8.4E-06	3.2E-06	7.4E-06	6.0E-05
1,2,3,4,7,8-HxCDD						3.8E-06						3.1E-06
1,2,3,6,7,8-HxCDD					1.7E-06	1.4E-05						7.8E-06
1,2,3,7,8,9-HxCDD						2.2E-06						3.1E-06
2,3,7,8-TCDF			6.1E-06		2.3E-06	1.9E-05			2.0E-06		1.3E-06	1.1E-05
2,3,4,7,8-PeCDF		1.1E-06	8.8E-06	1.5E-06	3.4E-06	2.8E-05				1.1E-06	2.6E-06	2.1E-05
1,2,3,4,7,8-HxCDF						1.4E-06						3.1E-06
1,2,3,6,7,8-HxCDF						1.6E-06						2.5E-06
1,2,3,7,8,9-HxCDF												2.8E-06
2,3,4,6,7,8-HxCDF						1.7E-06						3.6E-06
Total Number	6	10	16	12	15	29	1	4	11	12	15	30

[a] Mean U.S. per capita consumption rate of uncooked freshwater and estuarine fish, equivalent to 12 8-oz meals per year (USEPA 2000a)

[b] 90th percentile .US. per capita consumption rate of uncooked freshwater and estuarine fish, equivalent to 28 8-oz meals per year (USEPA 2000a

[c] 99th percentile .US. per capita consumption rate of uncooked freshwater and estuarine fish, equivalent to 19 8-oz meals per month (USEPA 2000a

Table 5-11. Chemicals exceeding excess cancer risk of 1.0E-6 for various consumption rates and exposure duration of 70 years

	Excess Cancer Risk by Consumption Rate (g/day)								
	Bass Fillet			Carp Fillet			Carp Whole Body		
	7.5[a]	17.5[b]	142.4[c]	7.5[a]	17.5[b]	142.4[c]	7.5[a]	17.5[b]	142.4[c]
Metals									
Total inorganic arsenic		1.2E-06	9.9E-06					2.1E-06	1.7E-05
PAHS									
Benz(a)]anthracene									1.2E-06
Benz(bjk]fluoranthenes									2.5E-06
Benzo(a)pyrene								2.4E-06	1.9E-05
Indeno(1,2,3-cd)pyrene									1.4E-06
Pesticides									
Aldrin						2.8E-06	2.3E-06	5.5E-06	4.5E-05
alpha-HCH									2.2E-06
Chlordane (total)			1.2E-06			6.7E-06		1.8E-06	1.5E-05
Dieldrin			2.6E-06	3.1E-06	7.2E-06	5.9E-05	6.3E-06	1.5E-05	1.2E-04
DDD total						5.1E-06		1.1E-06	9.1E-06
DDE total		1.4E-06	1.1E-05	6.2E-06	1.4E-05	1.2E-04	6.9E-06	1.6E-05	1.3E-04
DDT total			1.2E-06			1.3E-06			2.7E-06
gamma HCH			2.1E-06			2.4E-06			3.0E-06
Heptachlor epoxide						3.1E-06			5.7E-06
Hexachlorobenzene			2.6E-06		1.0E-06	8.5E-06		2.1E-06	1.7E-05
PCBs									
PCB 77						1.2E-06			2.4E-06
PCB 105		1.8E-06	1.5E-05	1.7E-06	4.0E-06	3.3E-05	3.5E-06	8.1E-06	6.6E-05
PCB 114			6.6E-06		1.8E-06	1.5E-05	1.5E-06	3.6E-06	2.9E-05
PCB 118	2.5E-06	5.8E-06	4.7E-05	6.5E-06	1.5E-05	1.2E-04	1.3E-05	3.1E-05	2.5E-04
PCB 123						4.6E-06			7.3E-06
PCB 126	5.2E-06	1.2E-05	9.9E-05	1.5E-05	3.6E-05	2.9E-04	2.6E-05	6.0E-05	4.8E-04
PCB 156/157	2.0E-06	4.6E-06	3.7E-05	5.1E-06	1.2E-05	9.8E-05	9.8E-06	2.3E-05	1.9E-04
PCB 167									1.8E-06
PCB 169		1.5E-06	1.2E-05	1.9E-06	4.4E-06	3.6E-05	3.9E-06	9.1E-06	7.4E-05
PCB 189						1.6E-06			3.5E-06
Adjusted Aroclors	5.1E-06	1.2E-05	9.7E-05	1.4E-05	3.2E-05	2.6E-04	2.9E-05	6.7E-05	5.5E-04
Dioxins/Furans									
2,3,7,8-TCDD	2.1E-06	4.8E-06	3.9E-05	6.5E-06	1.5E-05	1.2E-04	1.4E-05	3.3E-05	2.7E-04
1,2,3,7,8-PeCDD	1.8E-06	4.2E-06	3.4E-05	7.2E-06	1.7E-05	1.4E-04	1.8E-05	4.2E-05	3.4E-04
1,2,3,4,7,8-HxCDD					1.2E-06	1.0E-05	1.2E-06	2.9E-06	2.4E-05
1,2,3,6,7,8-HxCDD				2.0E-06	4.7E-06	3.8E-05	5.1E-06	1.2E-05	9.7E-05
1,2,3,7,8,9-HxCDD						3.3E-06		1.4E-06	1.1E-05
1,2,3,4,6,7,8-HpCDD						6.7E-06		2.2E-06	1.8E-05
2,3,7,8-TCDF			5.1E-06		1.6E-06	1.3E-05	1.6E-06	3.8E-06	3.1E-05
1,2,3,7,8-PeCDF						1.6E-06			3.6E-06
2,3,4,7,8-PeCDF		1.1E-06	9.1E-06	2.4E-06	5.7E-06	4.6E-05	5.4E-06	1.3E-05	1.0E-04
1,2,3,4,7,8-HxCDF						4.9E-06		1.5E-06	1.2E-05
1,2,3,6,7,8-HxCDF								1.0E-06	8.3E-06
2,3,4,6,7,8-HxCDF									6.1E-06
1,2,3,4,6,7,8-HpCDF									1.4E-06
Total	6	11	18	12	16	29	16	25	39

Table 5-11, continued

	Excess Cancer Risk by Consumption Rate (g/day)											
	Pikeminnow Fillet			Pikeminnow Whole Body			Sucker Fillet			Sucker Whole Body		
	7.5[a]	17.5[b]	142.4[c]	7.5[a]	17.5[b]	142.4[c]	7.5[a]	17.5[b]	142.4[c]	7.5[a]	17.5[b]	142.4[c]
Metals												
Total inorganic arsenic								1.5E-06	1.2E-05	3.1E-06	7.3E-06	5.9E-05
PAHS												
Dibenz(ah)anthracene						3.9E-06		1.5E-06	1.2E-05			
Pesticides												
Aldrin	1.2E-05	2.8E-05	2.2E-04	2.5E-06	5.9E-06	4.8E-05				2.0E-06	4.7E-06	3.8E-05
alpha-HCH						2.6E-06					2.3E-06	1.9E-05
Chlordane (total)			1.9E-06		1.0E-06	8.4E-06					1.4E-06	1.1E-05
Dieldrin		2.1E-06	1.7E-05	2.8E-06	6.5E-06	5.3E-05		1.7E-06	1.4E-05	5.8E-06	1.4E-05	1.1E-04
DDD total			1.3E-06			3.7E-06			1.9E-06			7.6E-06
DDE total		1.9E-06	1.5E-05	3.1E-06	7.3E-06	6.0E-05		1.8E-06	1.5E-05	2.8E-06	6.5E-06	5.3E-05
DDT total						1.2E-06					1.4E-06	1.1E-05
gamma-HCH			2.9E-06			2.5E-06						4.1E-06
Heptachlor epoxide						2.0E-06						5.2E-06
Hexachlorobenzene			3.3E-06		1.2E-06	9.4E-06					1.5E-06	1.3E-05
PCBs												
PCB 77			1.1E-06			3.1E-06						2.0E-06
PCB 105	1.3E-06	3.0E-06	2.4E-05	3.5E-06	8.2E-06	6.7E-05		1.4E-06	1.2E-05	2.8E-06	6.6E-06	5.4E-05
PCB 114		1.4E-06	1.2E-05	1.6E-06	3.6E-06	2.9E-05			5.0E-06	1.0E-06	2.4E-06	2.0E-05
PCB 118	4.3E-06	1.0E-05	8.1E-05	1.3E-05	3.0E-05	2.4E-04	2.1E-06	4.8E-06	3.9E-05	8.7E-06	2.0E-05	1.7E-04
PCB 123			2.0E-06			5.6E-06			1.5E-06			6.2E-06
PCB 126	1.1E-05	2.7E-05	2.2E-04	3.2E-05	7.4E-05	6.0E-04				2.2E-05	5.2E-05	4.2E-04
PCB 156/157	3.4E-06	8.0E-06	6.5E-05	9.8E-06	2.3E-05	1.9E-04	1.5E-06	3.4E-06	2.8E-05	6.5E-06	1.5E-05	1.2E-04
PCB 167						1.6E-06						1.0E-06
PCB 169	1.0E-06	2.4E-06	2.0E-05	3.4E-06	7.9E-06	6.4E-05		1.3E-06	1.0E-05	2.7E-06	6.4E-06	5.2E-05
PCB 189						2.6E-06						1.9E-06
Adjusted Aroclors	6.2E-06	1.4E-05	1.2E-04	1.9E-05	4.5E-05	3.6E-04				2.1E-05	5.0E-05	4.1E-04
Dioxins/Furans												
2,3,7,8-TCDD	2.2E-06	5.2E-06	4.2E-05	6.4E-06	1.5E-05	1.2E-04	1.4E-06	3.2E-06	2.6E-05	6.0E-06	1.4E-05	1.1E-04
1,2,3,7,8-PeCDD	3.1E-06	7.2E-06	5.9E-05	9.7E-06	2.3E-05	1.8E-04	1.0E-06	2.4E-06	2.0E-05	7.4E-06	1.7E-05	1.4E-04
1,2,3,4,7,8-HxCDD					1.1E-06	8.8E-06						7.1E-06
1,2,3,6,7,8-HxCDD				1.7E-06	4.0E-06	3.2E-05					2.2E-06	1.8E-05
1,2,3,7,8,9-HxCDD						5.0E-06						7.2E-06
1,2,3,4,6,7,8-HpCDD			1.7E-06									
2,3,7,8-TCDF		1.8E-06	1.4E-05	2.3E-06	5.4E-06	4.4E-05			4.6E-06	1.3E-06	3.1E-06	2.5E-05
1,2,3,7,8-PeCDF						1.5E-06						2.0E-06
2,3,4,7,8-PeCDF	1.1E-06	2.5E-06	2.1E-05	3.4E-06	7.9E-06	6.4E-05				2.6E-06	6.0E-06	4.9E-05
1,2,3,4,7,8-HxCDF						3.2E-06						7.2E-06
1,2,3,6,7,8-HxCDF						3.8E-06						5.9E-06
1,2,3,7,8,9-HxCDF												6.5E-06
2,3,4,6,7,8-HxCDF						4.0E-06					1.0E-06	8.5E-06
Total	10	14	21	15	18	33	4	10	14	15	21	34

[a] Mean U.S. per capita consumption rate of uncooked freshwater and estuarine fish, equivalent to 12 8-oz meals per year (USEPA 2000a)

[b] 90th percentile .US. per capita consumption rate of uncooked freshwater and estuarine fish, equivalent to 28 8-oz meals per year (USEPA 2000a

[c] 99th percentile .US. per capita consumption rate of uncooked freshwater and estuarine fish, equivalent to 19 8-oz meals per month (USEPA 2000a

Recreational Anglers

A total of 18 chemicals exceeded an ARL of 1.0E-06 for the recreational angler exposure scenario which assumed a 30-year exposure duration and a fish consumption rate of 17.5 grams per day (Table 5-10). These chemicals were from all chemical groups analyzed except PAHs. The number of chemicals that exceeded the ARL varied among tissue type and fish species. Whole body tissue had a higher number of chemicals exceeding the ARL than fillet tissue. For fillet tissue the number of chemicals with excess cancer risk estimates exceeding the ARL was lowest in sucker (4), followed in increasing order by bass (6), pikeminnow (10), and carp (12). Six chemicals—aldrin, PCB 118, PCB 126, Aroclors, 2,3,7,8-TCDD, and 1,2,3,7,8-PeCDD—had an excess cancer risk estimate in at least one fish species and tissue type that exceeded 1.0E-05. The highest chemical–specific excess cancer risk estimate under this scenario was 3.2E-05 for PCB 126 in pikeminnow whole-body tissue.

A total of 26 chemicals exceeded an ARL of 1.0E-06 for the recreational angler exposure scenario with a 70-year exposure duration and a fish consumption rate of 17.5 grams per day (Table 5-11). These chemicals were from all chemical groups analyzed. The number of chemicals that exceeded the ARL varied among tissue type and fish species. Whole body tissue had a higher number of chemicals exceeding the ARL than fillet tissue. For fillet tissue the number of chemicals with excess cancer risk estimates exceeding the ARL was lowest in sucker (10), followed in increasing order by bass (11), pikeminnow (14), and carp (25). Eleven chemicals—aldrin, dieldrin, DDE, PCB 118, PCB 126, PCB 156/157, Aroclors, 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, 1,2,3,7,8-HxCDD, and 2,3,4,7,8-PeCDF—had an excess cancer risk estimate in at least one fish species and tissue type that exceeded 1.0E-05. The highest chemical–specific excess cancer risk estimate under this scenario was 7.4E-05 for PCB 126 in pikeminnow whole-body tissue.

Subsistence Anglers

A total of 36 chemicals exceeded an ARL of 1.0E-06 for the subsistence angler exposure scenario which assumed a 30-year exposure duration and a fish consumption rate of 142.4 grams per day (Table 5-10). These chemicals were from all chemical groups analyzed. The number of chemicals that exceeded the ARL varied among tissue type and fish species. Whole body tissue had a higher number of chemicals exceeding the ARL than fillet tissue. For fillet tissue the number of chemicals with excess cancer risk estimates exceeding the ARL was lowest in sucker (11), followed in increasing order by bass (14), pikeminnow (16), and carp (25). Five chemicals—PCB 118, PCB 126, Aroclors, 2,3,7,8-TCDD, and 1,2,3,7,8-PeCDD—had an excess cancer risk estimate in at least one fish species and tissue type that exceeded 1.0E-04. The highest chemical–specific excess cancer risk estimate under this scenario was 2.6E-04 for PCB 126 in pikeminnow whole-body tissue.

A total of 40 chemicals exceeded an ARL of 1.0E-06 for the subsistence angler exposure scenario which assumed a 70-year exposure duration and a fish consumption rate of 142.4 grams per day (Table 5-11). These chemicals were from all chemical groups analyzed. The number of chemicals that exceeded the ARL varied among tissue type and fish species. Whole body tissue had a higher number of chemicals exceeding the ARL than fillet tissue. For fillet tissue the number of chemicals with excess cancer risk estimates exceeding the ARL was lowest in sucker (14), followed in increasing order by bass (18), pikeminnow (21), and carp (29). Ten chemicals—aldrin, dieldrin, DDE, PCB 118, PCB 126, PCB 156/157, Aroclors, 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, and 2,3,4,,7,8-PeCDF—had an excess cancer risk estimate in at least one fish species and tissue type that exceeded 1.0E-04. The highest chemical-specific excess cancer risk estimate under this scenario was 6.0E-04 for PCB 126 in pikeminnow whole-body tissue.

Chemical Percent Contribution to Total Carcinogenic Risk

The percent contribution to the total excess cancer risk for each chemical group and for individual chemicals within each group is shown in Table 5-12. The percent contribution of PCBs dominated the total excess cancer risk estimates and ranged from 48 to 72 percent of the total cancer risk. This was followed, in decreasing order, by dioxins/furans (15–31 percent), pesticides (6–29 percent), metals (0–6.8 percent), and PAHs (0–0.8 percent).

Risk estimates for both PCB congeners and Aroclors showed that the congeners contributed the greatest percentage of the risk within this chemical group. The percent contribution of the congeners ranged from 68 to 77 percent of the total PCB risk for all species samples except sucker fillet where congeners contributed 100 percent of the PCB risk; Aroclors were not detected in this tissue type. PCB 126 contributed the greatest excess cancer risk in this study; this chemical contributed between 16 and 27 percent of the cancer risk for all species and sample types except sucker fillet, where it was not detected.

Two chemicals—1,2,3,7,8-PeCDD and 2,3,7,8-TCDD—contributed the greatest percentage of the excess cancer risk for dioxins and furans. 1,2,3,7,8-PeCDD contributed between 6.3 to 11 percent of the cancer risk for all species and sample types, while 2,3,7,8-TCDD contributed between 5.4 and 8.9 percent of the cancer risk for all species and sample types. Within the pesticide chemical group, total DDE contributed the greatest percentage of the cancer risk for all samples except pikeminnow fillet and sucker whole-body. In pikeminnow fillet tissue, the excess cancer risk attributed to aldrin, 24 percent, was equal to that of PCB 126. In sucker whole-body tissue, dieldrin was the pesticide that contributed the greatest percentage of the total excess cancer risk. Within the trace metal chemical group, total inorganic arsenic contributed between 0 and 6.8 percent of the total excess cancer risk. Within the PAH chemical group, benzo(a)pyrene contributed the highest percentage of the excess cancer risk (0.7 percent).

Table 5-12. Percent contribution of contaminant groups and individual chemicals with toxicity values to excess cancer risk

	Bass	Carp		Pikeminnow		Sucker	
Total Cancer Risk	Fillet	Fillet	Whole Body	Fillet	Whole Body	Fillet	Whole Body
Metals	**2.3**	**nd**	**0.6**	**nd**	**nd**	**6.8**	**3**
Total inorganic arsenic	2.3	nd	0.6	nd	nd	6.8	3
Other Metals [a]	nd	nd	nd	nd	nd	nd	nd
PAHs	**nd**	**nd**	**0.8**	**nd**	**0.2**	**nd**	**0.1**
Benzo(a)pyrene	nd	nd	0.7	nd	nd	nd	0.1
Other PAHs [b]	nd	nd	0.2	nd	0.2	nd	nd
Pesticides	**6**	**15**	**12**	**29**	**8.5**	**17**	**14**
Aldrin	nd	0.2	1.5	24	2.2	nd	1.9
Dieldrin	1.7	4.1	4.1	1.8	2.4	7.6	5.6
DDE total	2.5	8.3	4.4	1.7	2.7	8.1	2.7
Other Pesticides [c]	1.8	1.9	1.9	1.1	1.4	1.3	3.6
PCBs	**72**	**59**	**55**	**57**	**70**	**48**	**63**
Adjusted Aroclors [d]	22	19	18	13	16	nd	20
PCB congeners	50	40	37	44	54	48	43
105	3.3	2.3	2.2	2.6	3	6.5	2.7
114	1.5	1.1	1	1.2	1.3	2.8	1
118	11	8.7	8.5	8.8	11	22	8.4
126	22	20	16	24	27	nd	21
169	2.8	nd	2.5	nd	2.9	nd	2.6
156/157	8.5	6.9	6.3	7	8.3	15	6.2
Other PCBs [e]	0.5	1.3	1.5	1.7	1.9	4.2	1.6
Dioxins/furans	**20**	**27**	**31**	**15**	**21**	**28**	**20**
1,2,3,6,7,8-HxCDD	nd	2.7	3.3	nd	1.4	nd	0.9
1,2,3,7,8-PeCDD	7.8	9.7	12	6.3	8.2	11	7
2,3,7,8-TCDD	8.9	8.7	8.9	4.6	5.4	15	5.7
2,3,4,7,8-PeCDF	2.1	3.3	3.5	2.2	2.9	nd	2.5
2,3,7,8-TCDF	1.1	0.9	1	1.5	2	2.5	1.3
Other Dioxin/furans [f]	nd	1.9	2.9	0.2	1.5	0.3	2.5

NOTE: nd = chemical(s) were not detected

[a] Sum of the percent contribution of mercury and zinc
[b] Sum of the percent contribution of benz(a)anthracene, benzo(bjk)fluoranthenes, chrysene, and indeno(1,2,3-cd)pyrene
[c] Sum of the percent contribution of alpha-HCH, beta-HCH, gamma-HCH, heptachlor, heptachlor epoxide, hexachlorobenzene, chlordane (total), DDD, and DDT
[d] Contribution of by non-dioxin-like PCB congeners
[e] Sum of the percent contribution of PCB 77, PCB 123, PCB 167, and PCB 189
[f] Sum of the percent contribution of 1,2,3,4,6,7,8-HpCDD, 1,2,3,4,6,7,8-HpCDF, 1,2,3,4,7,8,9-HpCDF, 1,2,3,4,7,8-HxCDD, 1,2,3,4,7,8-HxCDF, 1,2,3,6,7,8-HxCDF, 1,2,3,7,8,9-HxCDD, 1,2,3,7,8,9-HxCDF, 1,2,3,7,8-PeCDF, 2,3,4,6,7,8-HxCDF, OCDD, and OCDF

6.0 UNCERTAINTY EVALUATION

6.1 INTRODUCTION

There are several types of uncertainties associated with risk assessments, which can be grouped into three categories. First, the selection of the chemicals that were analyzed; second, uncertainties inherent in the exposure assessment; and third, uncertainties inherent in the toxicity values used to characterize risk (USEPA 1989). An uncertainty evaluation is included to assist the reader in assessing the direction and magnitude by which risk estimates are affected by the assumptions and parameters selected to characterize risk. This section provides a discussion of some of the important uncertainties in this risk assessment associated with exposure and toxicity assumptions.

6.2 UNCERTAINTY IN EXPOSURE ASSUMPTIONS

Exposure assumptions for the three scenarios evaluated in this risk assessment—general public, recreational anglers, and subsistence anglers— were based on USEPA and ODEQ guidance and are presented in Table 3-2. Little information currently exists on fishing practices and consumption rates of fish caught within the WFWF reach of the Willamette River. As a result, there is considerable uncertainty associated with the selection of the exposure parameters used to estimate risk in this report. In most cases, exposure parameters were selected to be conservative to ensure that a reasonable maximum exposure to chemicals in fish tissue was evaluated.

6.2.1 Exposure Duration

Exposure duration is defined as the time period over which an individual is exposed to one or more contaminants. Two defaults were used for the risk assessment: 70 years, which represents the average lifetime exposure duration, and 30 years, which represents the 90th percentile length of time that an individual stays at one residence (USEPA 1997c). The cancer risk estimates for an individual who consumes fish over an exposure duration that differs from the ones used in this report (ED_{new}) can be determined using the following equation:

$$ECR_{new} = ECR_{70} \times \frac{ED_{new}}{ED_{70}} \qquad \text{(Equation 5)}$$

where:

ECR_{new} = Excess cancer risk for the new exposure duration
ECR_{70} = Excess cancer risk estimate for a lifetime exposure duration of 70 years
ED_{new} = Individual exposure duration in years
ED_{70} = Default lifetime exposure duration of 70 years

Equation 5 shows that the excess cancer risk will change in direct proportion to the ratio of the new and default exposure durations. For example, if an exposure duration of 9 years was selected, which is the median length of time an individual stays at one residence, the lifetime exposure cancer risk estimates would be multiplied by a factor of 0.13 (9 years ÷ 70 years = 0.13) to obtain revised cancer risk estimates for a 9-year exposure duration. All total excess cancer risk estimates for the fish species and tissue types evaluated in this report would still exceed an ARL of 1.0E-06 if a duration of 9 years was assumed for exposure to the carcinogenic chemicals measured in fish tissue.

6.2.2 Sample Type

Information on the portions of fish that are consumed by individuals is limited. Respondents to the qualitative fish consumption survey conducted by EVS (1998b) for the WFWF reach of the Willamette River indicated that all ethnic groups consume fillet tissue; however, other parts of the fish are also consumed (Table 6-1). The reverse trend was observed for noncancer risk estimates, where neurological and reproductive/ developmental risks were on average 1.8 times higher for fillet tissue than for whole-body tissue. These results suggest that the risk estimates for cancer may vary by factors ranging from 2 to 11, and noncancer risk estimates by a factor of 2, depending upon which tissue type, fillet or whole body, better represents the portion of the fish being consumed.

Table 6-1. Parts of fish consumed by various ethnic groups

	Entire Fish	Muscle (Fillet)	Skin	Broth	Other (Specific)
African American		✓	✓		
Asian	✓	✓	✓	✓	✓ (eyes, eggs)
Caucasian		✓			
Russian	✓	✓	✓	✓	
Native American	✓	✓	✓	✓	✓ (eyes, eggs)

SOURCE: EVS 1998b

6.2.3 Consumption Rate

Quantitative information on fish consumption rates in the WFWF reach of the Willamette River are not available. The ingestion rates assumed for individuals in this risk assessment are based on national per capita consumption of estuarine and freshwater fish (USEPA 2000). Mean, 90th percentile, and 99th percentile ingestion rates for children, women of childbearing age, and adults were selected to evaluate potential risks over a range of possible ingestion rates. The extent to which the ingestion rates selected for this risk assessment are representative of the actual consumption practices of individuals consuming fish from the study are unknown.

6.2.4 Multiple Species Consumption Patterns

Risk estimates were presented based on the consumption of individual fish species and tissue types. However, it should be noted that an individual's diet could be comprised of multiple fish species. A mixed-diet scenario was not evaluated for this risk assessment because of the lack of data on which to develop it. However, all carcinogenic risk estimates presented in Section 5.0 exceeded an ARL of 1.0E-06 for all fish species. Therefore, any consumption patterns that included a combination of these fish species would still exceed an ARL if the same default values were used.

6.2.5 Uncertainty in Exposure Point Concentrations

The average concentrations of chemicals measured in fish tissue were used as the exposure point concentrations to assess potential risks. There are several sources of uncertainty inherent in the use of these concentrations to estimate risk over the long exposure periods assumed in this risk assessment.

Seasonal Effects

The fish collected for this risk assessment were collected from August 11 to 18, 1999. Chemical concentrations in the tissue of fish species can vary over time due to biological and biochemical changes in organism activities, fluctuating chemical concentrations, and bioavailability (Waid 1986; Olsson et al. 1978). For example, spawning has been shown to reduce whole-body tissue concentrations of lipophilic compounds due to the transfer of chemical to gametes (Guiney et al. 1979; Niimi 1983). In chinook salmon, spawning has been shown to eliminate 22 to 40 percent of organochlorine chemicals previously bioaccumulated (Miller 1994). For other fish species, repeated spawning could decrease chlorinated hydrocarbon and PCB concentrations in tissues over time (Waid 1986). The seasonal range of chemical concentrations in the target fish species evaluated in this risk assessment is not known. The risk estimates presented in this report could increase or decrease depending upon how concentrations vary over time and when these species are collected for human consumption.

Extrapolation of Concentrations

Another source of uncertainty for this risk assessment involves the use of the average chemical concentrations for fish collected over a short period of time to estimate human exposure over 30- and 70-year durations. If average chemical concentrations in fish tissue have changed over time, or are likely to change in the future, the risk estimates presented in this report may either underestimate or overestimate the risk to individuals. The small amount of existing historical data on chemical contaminants in fish within the Willamette River is insufficient to reliably evaluate trends in chemical concentrations. If the data collected in this study are used to assess health risks in the future, and chemical concentrations in fish decline in the future, the risk estimates presented in this report will likely overestimate health risks associated with consuming fish.

Sample Size

The size of the fish analyzed in this study provides another source of uncertainty in the risk estimates. Fish were collected such that composite samples contained individual fish of similar size. Older fish, which have longer exposure durations, may have higher tissue concentrations of chemicals that bioconcentrate over time (Gutenmann et al. 1992; Armstrong and Sloan 1980; Hansen et al. 1982). Fish length has been positively correlated with total PCB concentrations in chinook salmon (Miller 1994) and with Aroclor PCBs, dioxins/furans, and mercury concentrations in freshwater fish (EVS 1998a; Munn and Short 1997; Gilmour and Riedel 2000). The risk estimates for individuals that regularly consume target species that are smaller or larger than the sizes analyzed in this study may vary from risk estimates presented in this report.

Oregon fishing regulations do not specify catch limits or size restriction on carp, largescale sucker, or northern pikeminnow for the Willamette River (ODFW 2000).

However, catch and size restrictions are mandated for smallmouth bass. State regulations allow a daily limit of five bass, no more than three of which can exceed 15 inches in length. The bass analyzed for this study averaged 9.2 inches in length. The risk estimates provided in this report may underestimate the risks for individuals that regularly consume larger bass.

Effects of Cooking

This risk assessment makes the conservative assumption that skin and fatty areas of the fish are not removed during filleting, and that there is no net reduction in contaminant concentrations during cooking. Anglers who prepare fillets by skinning and trimming away the fatty areas may reduce their exposure to lipophilic contaminants by as much as 60 percent (Gall and Voiland 1990). It has also been shown that cooking the fish may also affect exposure concentrations, depending on the cooking methods (Skea et al. 1979; Zabik et al. 1979; USEPA 1997a). Although local methods of preparation were not available to modify exposure levels, USEPA has summarized contaminant reductions of various chemicals due to skinning, trimming, and cooking for a variety of fish species (USEPA 1997a). Two of these species were targeted for this risk assessment, bass and carp. Table 6-2 shows the range of percent reduction of contaminants for which data were available and which were measured in this study.

Table 6-2. Range of percent reduction in carp and bass tissues due to cooking and preparation activities

Chemical	Range of Reduction (%)	Reference
PCBs	16-80	Skea et al. 1979
Dioxins/furans	30-50	Zabik and Zabik 1995
DDE	16-75	Skea et al. 1979
Chlordane	17-51	Zabik et al. 1993
Dieldrin	56-76	Zabik et al. 1993
Heptachlor epoxide	82[a]	Zabik et al. 1993
Mirex	21-80	Skea et al. 1979

[a] Range not available

In an effort to show the potential effects of cooking on risk estimates based on uncooked tissue, the values presented in Table 6-2 were applied to concentrations of the associated chemicals or chemical groups to adjust exposure point estimates. Table 6-3 compares the total excess cancer risk estimates before and after cooking for the general population. Reducing exposure concentrations for the chemicals presented in Table 6-2 reduced total excess cancer risk estimates, but did not reduce any values to less than an ARL of 1.0E-06 for any of the target populations.

Table 6-3. Comparison of excess cancer risk estimates for the general population prior to and after cooking fish tissue

	Bass Fillet	
	Prior to Cooking	After Cooking
Pesticides	6.0E-07	2.6E-07 – 3.6E-07
PCB adjusted Aroclors	2.2E-06	4.4E-07 – 1.8E-06
PCB congeners	4.9E-06	9.9E-07 – 4.1E-06
Dioxins/furans	2.0E-06	9.9E-07 – 1.4E-06
Total risk	9.9E-06	2.9E-06 – 7.9E-06

	Carp Fillet		Carp Whole Body	
	Prior to Cooking	After Cooking	Prior to Cooking	After Cooking
Pesticides	4.7E-06	1.5E-06 – 2.3E-06	7.9E-06	3.4E-06 – 4.6E-06
PCB adjusted Aroclors	6.0E-06	1.2E-06 – 5.0E-06	1.2E-05	2.5E-06 – 1.0E-05
PCB congeners	1.3E-05	2.5E-06 – 1.1E-05	2.5E-05	5.0E-06 – 2.1E-05
Dioxins/furans	8.7E-06	4.3E-06 – 6.1E-06	2.1E-05	1.0E-05 – 1.5E-05
Total risk	3.2E-05	9.6E-06 – 2.4E-05	6.7E-05	2.2E-05 – 5.1E-05

	Pikeminnow Fillet		Pikeminnow Whole Body	
	Prior to Cooking	After Cooking	Prior to Cooking	After Cooking
Pesticides	6.0E-06	5.5E-06 – 5.6E-06	4.3E-06	2.3E-06 – 2.8E-06
PCB adjusted Aroclors	2.7E-06	5.3E-07 – 2.2E-06	8.2E-06	1.6E-06 – 6.9E-06
PCB congeners	9.1E-06	1.8E-06 – 7.7E-06	2.7E-05	5.4E-06 – 2.3E-05
Dioxins/furans	3.1E-06	1.6E-06 – 2.2E-06	1.1E-05	5.4E-06 – 7.6E-06
Total risk	2.1E-05	9.4E-06 – 1.8E-05	5.1E-05	1.5E-05 – 4.0E-05

	Sucker Fillet		Sucker Whole Body	
	Prior to Cooking	After Cooking	Prior to Cooking	After Cooking
Pesticides	6.9E-07	2.0E-07 – 3.2E-07	6.2E-06	3.1E-06 – 4.0E-06
PCB adjusted Aroclors	0.0E+00	0.0E+00 – 0.0E+00	9.2E-06	1.8E-06 – 7.7E-06
PCB congeners	1.9E-06	3.9E-07 – 1.6E-06	1.9E-05	3.8E-06 – 1.6E-05
Dioxins/furans	1.1E-06	5.7E-07 – 8.0E-07	8.9E-06	4.5E-06 – 6.3E-06
Total risk	4.0E-06	1.4E-06 – 3.0E-06	4.5E-05	1.5E-05 – 3.5E-05

NOTE: Metals and PAHs were not adjusted for cooking and are not shown.

Tables 6-4 and 6-5 show new HIs for health endpoints which included chemicals or chemical groups listed in Table 6-2. Two health endpoints were assessed to determine the effects of cooking on the calculated hazard indices: immunological and hepatic. A third health endpoint, thyroid, which was comprised of mirex only, was not assessed because HI values prior to cooking were several orders of magnitude below 1.0 and cooking procedures would simply reduce this level further.

Table 6-4. The range of potential hazard indices for the immunological health endpoint for target populations after cooking fish tissue

	BASS	CARP		PIKEMINNOW		SUCKER	
	FILLET	FILLET	WHOLE BODY	FILLET	WHOLE BODY	FILLET	WHOLE BODY
General Population							
Adult	0.1–0.03	0.3–0.08	0.7–0.2	0.1–0.04	0.5–0.1	–	0.5–0.1
Child	0.1–0.02	0.3–0.07	0.6–0.1	0.1–0.03	0.4–0.1	–	0.4–0.1
Recreational Anglers							
Adult	0.3–0.06	0.7–0.2	[illegible]	0.3–0.08	[illegible]	–	[illegible]
Subsistence Anglers							
Adult	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	–	[illegible]
Child	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	–	[illegible]

NOTE: Shading indicates HI prior to cooking exceeded a value of one
Bold indicates HI values may decrease to <1.0 after cooking

Table 6-5. The range of potential hazard indices for the hepatic health endpoint for target populations after cooking fish tissue

	BASS	CARP		PIKEMINNOW		SUCKER	
	FILLET	FILLET	WHOLE BODY	FILLET	WHOLE BODY	FILLET	WHOLE BODY
General Population							
Adult	0.004-0.002	0.04-0.01	0.05-0.02	0.006-0.002	0.02-0.008	0.005-0.002	0.03-0.01
Child	0.004-0.002	0.03-0.01	0.04-0.02	0.005-0.002	0.02-0.007	0.004-0.001	0.02-0.009
Recreational Anglers							
Adult	0.01-0.004	0.08-0.03	0.1-0.04	0.01-0.005	0.05-0.02	0.01-0.004	0.06-0.02
Subsistence Anglers							
Adult	0.08-0.03	0.7-0.2	0.9-0.3	0.1-0.04	0.4-0.1	0.09-0.03	0.5-0.2
Child	0.1-0.04	0.9-0.3	1.1-0.4	0.1-0.05	0.5-0.2	0.1-0.04	0.6-0.2

NOTE: Shading indicates HI prior to cooking exceeded a value of one
Bold indicates HI values may decrease to <1.0 after cooking

For the immunological health endpoint, two target populations showed a potential reduction in HIs to a level less than 1.0. HIs for carp, pikeminnow, and sucker whole-body tissues consumed by recreational anglers could potentially be reduced by cooking methods to a value of less than 1.0. For subsistence anglers, cooking may reduce risk estimates for the immunological endpoint to less than 1.0 for bass fillet and pikeminnow fillet tissues.

For the hepatic endpoint, all values were less than 1.0 prior to cooking except for carp whole-body samples for adult and child subsistence anglers and carp fillet for child subsistence anglers. After contaminant reduction from cooking processes, these values may decrease to a level below 1.0 (Table 6-5).

Non-detected Values

For some chemicals and fish samples, the calculation of average exposure point concentrations relied upon sample data where the concentration was reported as not detected. If a chemical was detected at least once in a fish species and sample type, a value reported as not detected was assumed to be present at a concentration equal to one-half the detection limit. This practice increases the uncertainty of the resulting exposure point concentrations because the actual sample concentration may range from zero to the full detection limit. To evaluate this uncertainty, Tables 6-6 and 6-7 compare the noncarcinogenic hazard indices and excess carcinogenic risks, respectively, calculated by treating values reported as not detected as either a concentration equal to zero, one-half the detection limit, or the full detection limit. Most hazard indices do not change based on the different assumptions regarding non-detected values (Table 6-6). The largest percent change occurred for the renal health endpoint, for which the hazard index changed by 50 percent depending on how the non-detected values were treated. The treatment of non-detected values does not change conclusions about which health endpoints exceed a hazard index of 1.0.

The estimates of excess carcinogenic risk also exhibit negligible changes depending on how non-detected values are treated, and do not change the characterization of risk presented in Section 5.0 (Table 6-7).

Table 6-6. Hazard indices for noncarcinogenic health endpoints calculated using three different methods of treating values reported as not detected[a]

Endpoint	Non-detected value treated as:	Bass Fillet	Carp Fillet	Carp Whole Body	Pikeminnow Fillet	Pikeminnow Whole Body	Sucker Fillet	Sucker Whole Body
Metabolic	0	0.008	0.02	0.07	0.006	0.01	0.007	0.01
	½ DL	0.008	0.02	0.07	0.006	0.01	0.007	0.01
	DL	0.008	0.02	0.07	0.006	0.01	0.007	0.01
Hematopoietic	0	0.000003	nd	0.00002	0.000003	0.00001	0.000006	0.00002
	½ DL	0.000003	nd	0.00002	0.000003	0.00001	0.000006	0.00002
	DL	0.000003	nd	0.00002	0.000003	0.00002	0.000006	0.00002
Immunological	0	0.3	0.9	2	0.4	1	nd	1
	½ DL	0.3	0.9	2	0.4	1	nd	1
	DL	0.3	0.9	2	0.4	1	nd	1
Cardiovascular	0	0.002	nd	0.005	nd	nd	0.003	0.02
	½ DL	0.003	nd	0.005	nd	nd	0.003	0.02
	DL	0.003	nd	0.005	nd	nd	0.003	0.02
Renal	0	0.0007	0.000003	0.005	0.00001	0.003	0.00002	0.002
	½ DL	0.0007	0.000004	0.005	0.00001	0.003	0.00002	0.002
	DL	0.0007	0.000006	0.005	0.00001	0.004	0.00002	0.003
Hepatic	0	0.01	0.1	0.1	0.02	0.06	0.02	0.08
	½ DL	0.01	0.1	0.1	0.02	0.06	0.02	0.09
	DL	0.01	0.1	0.1	0.02	0.07	0.02	0.09
Neurological	0	0.9	0.6	0.3	2	0.9	0.4	0.3
	½ DL	0.9	0.6	0.3	2	0.9	0.4	0.3
	DL	0.9	0.6	0.3	2	0.9	0.4	0.3
Intestinal lesions	0	nd	nd	0.0002	0.0003	0.00003	nd	0.0008
	½ DL	nd	nd	0.0002	0.0003	0.00009	nd	0.0009
	DL	nd	nd	0.0003	0.0003	0.0001	nd	0.0009
Argyria	0	nd	nd	0.001	nd	nd	0.001	nd
	½ DL	nd	nd	0.001	nd	nd	0.001	0.001
	DL	nd	nd	0.001	nd	nd	0.001	0.001
Thyroid	0	0.00006	nd	0.0002	nd	0.0002	nd	nd
	½ DL	0.00006	nd	0.0002	nd	0.0002	nd	nd
	DL	0.00006	nd	0.0002	nd	0.0002	nd	nd
Reproductive/ developmental[b]	0	0.4	0.3	0.1	0.8	0.4	0.2	0.1
	½ DL	0.4	0.3	0.1	0.8	0.4	0.2	0.1
	DL	0.4	0.3	0.1	0.8	0.4	0.2	0.1

NOTE: DL = detection limit
nd = no chemicals comprising endpoint were detected

[a] Values for all health endpoints except reproductive/developmental were calculated for an ingestion rate of 17.5 g/day (29 8-oz meals/year).
[b] Values for reproductive/developmental endpoint was calculated for an ingestion rate of 7.36 g/day (13 8-oz meals/year).

Table 6-7. Excess cancer risk calculated by treating non-detected concentrations as zero, one-half the detection limit, and the full detection limit for chemicals detected at least once in a fish species and sample type

	Total Excess Cancer Risk		
Sample	ND=0	ND=1/2 DL	ND=DL
Bass fillet	5.3E-05	5.4E-05	5.5E-05
Carp fillet	1.7E-04	1.7E-04	1.7E-04
Carp whole body	3.6E-04	3.6E-04	3.7E-04
Pikeminnow fillet	1.1E-04	1.1E-04	1.1E-04
Pikeminnow whole body	2.7E-04	2.8E-04	2.8E-04
Sucker fillet	2.2E-05	2.2E-05	2.2E-05
Sucker whole body	2.3E-04	2.4E-04	2.5E-04

NOTE: Total excess cancer risk based on 17.5 g/d, 70 kg body weight, and 70-year exposure duration
DL = detection limit
ND = non-detected value

Usability of Data

The data quality assurance review for this study was discussed in Section 2.0. With the exception of two analyses for naphthalene, which could not be quantified, none of the data collected have been qualified as being unusable for the human health risk assessment. Twenty-one percent of the data collected in this study have been qualified as estimates (Table 2-6). Estimated data were considered usable for risk assessment purposes, although the uncertainty associated with risk estimates made from estimated data might be greater than assessments made from unqualified data. Nine percent of the sample analyses had concentrations reported as not detected with analytical detection limits that were higher than the study DQOs (Table 2-6). Both of these data QA issues mainly affected the analyses of PAHs. The risk estimates presented in Section 5.0 show that PAHs account for less than 1 percent of the total carcinogenic risk, and no PAH compounds have an HQ that exceeded 1.0. The QA issues associated with the PAH data collected for this study are unlikely to affect the characterization of the risk associated with eating fish from the Willamette River.

6.3 Uncertainty in Toxicity Assumptions

In addition to exposure parameters, a degree of uncertainty is also associated with toxicity assumptions that are incorporated into the risk assessment: toxicity values, TEFs, the treatment of measured Aroclors and congeners, and the treatment of measured DDT and its derivatives.

6.3.1 Toxicity Values

The toxicity values used in this risk assessment (i.e., RfDs and SFs) are derived from dose-response data (USEPA 1997a). They may be extrapolated from high-dose to low-dose models, laboratory animal studies, and/or subchronic studies. The extrapolation of toxicity values can contribute to uncertainty in the estimated values. In addition, toxicity values are chemical-specific and do not take into account interactive effects with other chemicals. While the use of uncertainty factors and upper-bound cancer risk estimates are intended to provide a margin of safety to account for extrapolation from various types of toxicity studies and the general human population, there is considerable uncertainty in the application of these toxicity values (North 1998). The estimates and assumptions used for these values may over- or underestimate carcinogenic or noncarcingenic risk.

6.3.2 Toxicity Equivalency Factors

TEF values were used for the 2,3,7,8-substitiuted dioxins and furans and dioxin-like PCB congeners measured in the study to calculate a 2,3,7,8-TCDD TEC concentration. Similarly, TEF values for several PAHs were used to derive a benzo(a)pyrene TEC concentration. TEF values contribute to uncertainty because the values are dependent upon several factors including the species, sex, strain, and age of laboratory test animals; the study duration; and specific responses (Safe 1990). They are typically an order-of-magnitude estimate relative to the toxicity of 2,3,7,8-TCDD or benzo(a)pyrene. Because PCB congeners contributed the greatest proportion of the carcinogenic risk estimate for all species (ranging from 37 to 53 percent), uncertainty associated with TEFs could have a substantial effect on the risk estimates characterized in this study.

The SF for 2,3,7,8-TCDD is being re-evaluated as part of a current review of dioxins and risk assessment. Changes to the SF would affect both the risk associated with 2,3,7,8-TCDD and the TEC concentrations from dioxins, furans, and dioxin-like PCB congeners. If the SF increases following the dioxin reassessments, carcinogenic risk estimates would also increase.

6.3.3 Uncertainty Associated with PCBs

For this risk assessment, two different measures of PCBs were analyzed: Aroclors, commercial mixtures of PCBs that are no longer being manufactured (USEPA 1996a), and PCB congeners. Three Aroclors were measured in fish tissues: Aroclor 1242, Aroclor 1254, and Aroclor 1260. Ten PCB congeners were measured that exert toxicity similar to 2,3,7,8-TCDD (dioxin-like PCBs). PCB 170 and PCB 180 were not considered dioxin-like PCBs because they currently do not have associated TEF values. Because Aroclors are a mixture of both dioxin-like and non-dioxin-like congeners, calculating and summing the risk associated with both Aroclors and with individual PCBs would likely overestimate carcinogenic risk by accounting for PCB congener risk both individually and within Aroclors. Therefore, an adjustment was made to Aroclors by subtracting the concentration of dioxin-like congeners from the total Aroclor concentration for each sample in order to calculate an adjusted total Aroclor concentration.

Table 6-8 compares total excess cancer risk estimates under four scenarios: 1) total risk includes both unadjusted Aroclors and dioxin-like congeners, 2) total risk includes only unadjusted Aroclors, 3) total risk includes only congeners, and 4) total risk includes adjusted Aroclors to represent only non-dioxin-like congeners, summed with the ten dioxin-like congeners. It should be noted, however, that the risk estimates derived from non-dioxin-like PCBs are likely to be overestimated, because the SF developed for Aroclors includes a contribution from dioxin-like PCB congeners (USEPA 1996a).

Table 6-8. Total excess cancer risk for various congener and Aroclor treatments

Sample	Unadjusted Aroclors Plus Congeners	Unadjusted Aroclors Only	Congeners Only	Adjusted Aroclors Plus Congeners
Bass fillet	5.5E-05	2.8E-05	4.2E-05	5.4E-05
Carp fillet	1.8E-04	1.1E-04	1.4E-04	1.7E-04
Carp whole body	3.7E-04	2.3E-04	3.0E-04	3.6E-04
Pikeminnow fillet	1.2E-04	6.6E-05	9.9E-05	1.1E-04
Pikeminnow whole body	2.8E-04	1.3E-04	2.3E-04	2.8E-04
Sucker fillet	2.2E-05	1.1E-05	2.2E-05	2.2E-05
Sucker whole body	2.5E-04	1.4E-04	1.9E-04	2.4E-04

NOTE: Total excess cancer risk based on 17.5 g/d, 70 kg body weight, and 70-year exposure duration

6.3.4 Aroclor 1254 vs. All Aroclors

The HQ for the immunological health endpoint was based on the toxicity of Aroclors. Two possible approaches for the estimation of immunological risk were available:

- Approach 1—the HQ could be estimated by summing the concentrations of all three Aroclors for each sample and utilizing the RfD for Aroclor 1254 to estimate risk
- Approach 2—the HQ could be estimated using the concentration of only Aroclor 1254 for each sample and the RfD for Aroclor 1254

The first approach was taken to provide a conservative evaluation of the risk from Aroclors by including data from Aroclor 1242 and Aroclor 1260, which do not have associated RfDs. Table 6-9 compares the noncarcinogenic risk estimate using both

Table 6-9. Comparison of hazard quotients for an immunological health endpoint based on alternative treatments of Aroclor data

	Based on Aroclor 1254 only	Based on the Summation of Aroclors
Bass fillet	0.2	0.3
Carp fillet	0.5	0.9
Carp whole body	1.0	1.8
Pikeminnow fillet	0.2	0.4
Pikeminnow whole body	0.5	1.3
Sucker fillet	0[a]	0[a]
Sucker whole body	0.7	1.3

NOTE: Risk based on 17.5 g/d and 70 kg body weight

[a] Aroclors not detected in samples.

methods. Risk estimates based on total Aroclor concentrations were higher than those based on Aroclor 1254 only. The largest change was found in pikeminnow whole-body samples where risk estimates increased by nearly a factor of 3 when all Aroclors were used for in the calculation.

6.3.5 DDT, DDD, and DDE

DDT and its derivatives, DDD and DDE, were measured in fish tissue samples. For noncarcinogenic risk estimates, a conservative approach was used which involved the summation of DDT, DDD, and DDE per sample (total DDT) and used the RfD associated with DDT to calculate an HQ. Alternatively, only DDT could have been used in the HQ because it alone has an RfD. DDT has been identified as having a hepatic health endpoint as based on the RfD value, and therefore the treatment of DDT and its derivatives will affect the HQ and the HI for hepatic toxicity. Table 6-10 compares the HQs and HIs using each method. In general, the HQ increased by two orders of magnitude when the summation of DDT and its derivatives were used. However, there was less impact to the hepatic HI, and most HIs increased by one order of magnitude. These increases did not exceed an HI greater than 1.0.

Table 6-10. Comparison of hazard quotients and hazard indices for a hepatic health endpoint based on alternative treatments of DDT, DDD, and DDE data

	HQ DDT	HQ TOTAL DDT	HI HEPATIC DDT	HI HEPATIC TOTAL DDT
Bass fillet	0.0008	0.01	0.004	0.01
Carp fillet	0.0009	0.09	0.02	0.1
Carp whole body	0.002	0.1	0.04	0.1
Pikeminnow fillet	0.0003	0.01	0.005	0.02
Pikeminnow whole body	0.0009	0.05	0.02	0.06
Sucker fillet	0[a]	0.01	0.003	0.02
Sucker whole body	0.008	0.05	0.04	0.09

NOTE: Risk based on 17.5 g/d and 70 kg body weight
Total DDT = sum of DDT, DDD, and DDE
HQ = hazard quotient
HI = hazard index

[a] DDT was not detected in samples.

6.4 SUMMARY

An uncertainty evaluation provides the reader with assistance in assessing the direction and magnitude of potential changes in risk estimates based on the chemical analyses and the uncertainty of the risk parameters. Table 6-11 summarizes the uncertainties discussed and applies a qualification of the impacts to risk estimates from each parameter. In general, most uncertainty factors could affect the risk estimates either by increasing or decreasing carcinogenic or noncarcinogenic risk. Exposure duration for noncancer risk and the treatment of detection limits appeared not to have substantial impacts on risk estimates. Altering the exposure duration to less than lifetime, cooking fish tissue, altering conservative toxicity values, and not using the conservative approach for summing Aroclors or DDT derivatives would decrease risk estimates. Collecting larger bass would likely increase risk estimates.

Table 6-11. Summary of the effects and bias of uncertainty parameters on risk estimates derived in this report

UNCERTAINTY PARAMETER	EFFECT ON RISK ESTIMATE	BIAS
Exposure duration	A lifetime exposure duration of 70 years was evaluated; ECR would decrease for exposure durations less than lifetime.	-
	Noncarcinogenic risk would not be affected based on the noncarcinogenic risk equation	0
Sample type	ECR for whole body tissue was greater than fillets by factors ranging from 2-11 showing that overall cancer risk may be higher for individuals that consume the entire fish; consumption of particular organs/tissues (e.g., eggs) were not assessed.	+/-
	ECR estimates varied 8-fold for fillet samples and 1.5-fold for whole-body samples. All ECR estimates exceeded an ARL of 1.0E-06.	+/-
	Noncarcinogenic risk for neurological and reproductive/ developmental endpoints in fillet tissue were on average 1.8 times higher than whole body tissue; noncancer risk estimates varied by 2-fold for these endpoints, depending on sample type	+/-
Consumption rate	Consumption rate was based on national default values representing the average, 90th percentile, and the 99th percentile. The extent to which default rates are representative of the study area is unknown.	+/-
Multiple-species diet	Risk was calculated based on consumption of a single fish species. Given the same ingestion rate, a diet comprised of multiple species may change both ECR and noncarcinogenic risk estimates	+/-
Seasonal variability	Fish were collected in August, 1999. Tissue concentrations may vary in fish, depending upon the season or life-history stage when fish are collected	+/-
Extrapolation of concentration	Risk estimates depend upon past and future trends in tissue concentrations. The average tissue concentrations may not be representative of fish tissue concentrations occurring over a lifetime.	+/-
Size of fish	Risk estimates may underestimate concentrations of some chemicals in bass.	+
	For other species, the effect is varied because size regulations are not in place and anglers may collect a variety of fish sizes.	+/-
Cooking	Risk assessment based on uncooked tissue samples. Cooking is likely to reduce tissue concentrations of chemicals of potential concern and therefore, risk estimates.	-
Non-detected chemicals	A range of treatment methods for non-detected chemicals was assessed; no substantial change in risk based on treatment type was determined	0
RfDs	Uncertainty is chemical dependant; incorporation of uncertainty and modifying factors results intended to provide a conservative RfD.	-
SF	Weight-of-evidence classification incorporates uncertainty into slope factors; further data may reduce the uncertainty factor and reduce the SF	-

UNCERTAINTY PARAMETER	EFFECT ON RISK ESTIMATE	BIAS
TEFs	TEFs are an order-of-magnitude estimate. Further data on chemical specific toxicity could vary risk estimates.	+/-
Adjusting Aroclors to reflect non-dioxin-like component for ECR estimates	Both Aroclors and dioxin-like congeners were measured. Risk estimates were compared between an adjusted Aroclor concentration reflecting only non-dioxin-like congeners so that dioxin-like congeners would not be incorporated into ECR from both Aroclors and individual congener concentrations. Adjustment decreases risk estimates. SFs, however, are based on Aroclors, which include dioxin-like congeners, and risk may be overestimated.	+/-
Summation of Aroclors for HQ estimates	Three Aroclors were measured: 1242, 1254, and 1260. Concentrations of all three Aroclors were summed for a total Aroclor concentration and the RfD for Aroclor 1254 was used. The summation provides a conservative approach to risk estimates and risk will decrease if only 1254 was used.	-
Summation of DDT derivatives for HQ	DDT, DDE, and DDD were summed for a total DDT concentration to provide a conservative estimate of risk; the RfD for DDT was used for calculations. If only DDT concentrations were used, HQs would decrease.	-

NOTE: ARL = acceptable risk level
ECR = excess cancer risk
HQ = hazard quotient
RfD = reference dose
SF = cancer slope factor
TEF = toxicity equivalency factor

7.0
REGIONAL AND HISTORICAL COMPARISONS OF CHEMICAL CONCENTRATIONS IN FISH

This section compares the chemical concentrations measured in the four species analyzed in this study with historical fish tissue data collected in the same WFWF reach of the Willamette River, other areas in the Willamette River, and the lower Columbia River. The five comparison areas are identified below:

- **WFWF**—middle Willamette River reach extending downstream from Wheatland Ferry (RM 72) to Willamette Falls (RM 26.5). The study area for this risk assessment
- **UWR**—upper Willamette River reach extending downstream from the city of Eugene (RM 185) to Wheatland Ferry (RM 72)
- **LWR**—lower Willamette River reach extending downstream from Willamette Falls (RM 26.5) to the river mouth (RM 0)
- **LCR**—lower Columbia River reach extending downstream from Bonneville Dam (RM 146) to the river mouth (RM 0)

The data for these comparisons were collected by eight studies that collected fish from 1988 to 1994 (USEPA 1992; Tetra Tech 1993; Curtis 1994; ODEQ 1994; Schuler 1994; Tetra Tech 1994; Tetra Tech 1996; Thomas 1997).

7.1 SELECTION OF CHEMICALS FOR COMPARISON

The sixteen chemicals that contributed the greatest potential risk to fish consumers based on the results of this risk assessment are discussed in this section. These chemicals of potential concern (COPC) were selected by the following criteria:

- Chemicals with a carcinogenic health endpoint that comprised greater than five percent of the total excess cancer risk and had an excess cancer risk estimate greater than 1.0E-06 in at least one of the four fish species analyzed in this study
- Chemicals with a noncarcinogenic health endpoint that comprised greater than five percent of a hazard index and had a hazard quotient greater than 1.0 in at least one of the four fish species analyzed in this study.

Appendix E provides minimum, maximum, average, standard deviation, and detection frequencies for these COPCs.

7.2 REGIONAL AND HISTORICAL COMPARISONS

This section compares average concentrations measured in the present study, WFWF (current), with average historical concentrations measured in the WFWF reach WFWF (historical) and other regional comparison areas. When data exists to make a comparison, shading is used to identify the area with the highest average chemical concentration. Comparisons for each of the fish species and tissue types analyzed in this study are described below and summarized in Tables 7-1 through 7-7.

7.2.1 Bass

Eight COPCs—mercury, aldrin, chlordane, DDE, dieldrin, heptachlor epoxide, Aroclor 1254, and Aroclor 1260—were analyzed in two composite samples of bass fillet analyzed in the current study and only a single sample of bass in each historical data set from the WFWF reach, lower Willamette River, and the lower Columbia River. Very little data is available for making comparisons. The majority of chemical concentrations have been reported as not detected (Table 7-1; Appendix E). Based on this limited data set, concentrations of mercury, Aroclor 1254, and Aroclor 1260 are higher in the current study than concentrations in bass collected in 1988 in the same section of the Willamette River. Concentrations of chlordane, dieldrin, and heptachlor epoxide measured in the current study are more than 10 times lower than concentrations measured in bass collected in 1990 from the lower Columbia River.

Table 7-1. Comparison of average chemical concentrations (± standard deviation) measured in bass fillet from WFWF (current) to historical average concentrations from other comparison areas

		Bass Fillet				
Chemical	Units	WFWF (current)	WFWF[a] (historical)	UWR	LWR[a]	LCR[b]
Total inorganic arsenic	µg/kg	3.3 ± 2.5				
Mercury	mg/kg	[illegible]	0.1			
Aldrin	µg/kg	nd (0.086)				nd (10)
Chlordane	µg/kg	2.1 ± 0.1	nd (5)		nd (3)	[illegible]
DDE	µg/kg	16.1 ± 2.8				[illegible]
Dieldrin	µg/kg	0.24 ± 0.007	nd (5)		4	[illegible]
Heptachlor epoxide	µg/kg	nd (0.009)	nd (5)		nd (3)	nd (10)
Aroclor 1254	µg/kg	[illegible]	nd (5)		nd (3)	
Aroclor 1260	µg/kg	[illegible]	nd (5)		nd (3)	
PCB 105	µg/kg	0.44 ± 0.035				
PCB 118	µg/kg	1.4 ± 0.21				
PCB 126	µg/kg	0.0033 ± 0.0009				
PCB 156/157	µg/kg	0.23 ± 0.03				
1,2,3,7,8-PeCDD	ng/kg	0.10 ± 0.007				
2,3,7,8-TCDD	ng/kg	0.12 ± 0.028				
TEC[c]	ng/kg	0.31 ± 0.022				

NOTE: nd = not detected; the value in parenthesis is the average detection limit
Shaded = study area with the highest chemical concentration when data are available for comparison

[a] ODEQ (1994): one sample.
[b] Schuler (1994): one sample.
[c] 2,3,7,8-TCDD toxicity equivalency concentration (TEC) calculated using toxicity equivalent factors recommended by the World Health Organization (Van den Berg et al. 1998).

7.2.2 Carp

Willamette Ferry – Willamette Falls Reach

Seven COPCs—mercury, aldrin, chlordane, dieldrin, heptachlor epoxide, Aroclor 1254, and Aroclor 1260—were analyzed in the one composite sample of carp fillet in the current study and nine samples collected within the WFWF reach during 1988-1989 (Table 7-2; Appendix E). Five chemicals—mercury, dieldrin, heptachlor epoxide, Aroclor 1254, and Aroclor 1260—were detected in the historical study. The concentrations of these chemicals measured in the current study are within one standard deviation of the historical average concentrations; therefore, current concentrations of these COPCs appear to be similar to the historical levels.

Table 7-2. Comparison of average chemical concentrations (± standard deviation) measured in carp fillet from WFWF (current) to historical average concentrations from other comparison areas

		Carp Fillet				
Chemical	Units	WFWF (current)	WFWF[a] (historical)	UWR	LWR	LCR[b]
Total inorganic arsenic	µg/kg	nd (3)				1
Mercury	mg/kg	[redacted]	0.17 ± 0.12	0.15 ± 0.05[a]		0.14
Aldrin	µg/kg	0.08	nd (2.4)	[redacted]	nd (2.4)	nd (0.01)
Chlordane	µg/kg	[redacted]	nd (1.5)	nd (26)[a]	nd (25)	
DDE	µg/kg	[redacted]			41 ± 35	130
Dieldrin	µg/kg	1.8	[redacted]	nd (2.3)[a]	nd (2)	nd (0.02)
Heptachlor epoxide	µg/kg	0.17	[redacted]	nd (2.3)[a]	nd (2)	nd (0.01)
Aroclor 1254	µg/kg	36	[redacted]	nd (27)[a]	nd (25)	nd (1.1)
Aroclor 1260	µg/kg	32	29 ± 38	nd (27)[a]	[redacted]	138
PCB 105	µg/kg	1		nd (2)[a]	[redacted]	
PCB 118	µg/kg	3.8				
PCB 126	µg/kg	0.009		nd (2)[a]	[redacted]	
PCB 156/157	µg/kg	0.600				
1,2,3,7,8-PeCDD	ng/kg	[redacted]				nd (1.1)
2,3,7,8-TCDD	ng/kg	[redacted]		0.34 ± 0.18[c]		nd (1.1)
TEC[d]	ng/kg	1.2			1.6 ± 1.8c[c]	[redacted]

NOTE: nd = not detected; the value in parenthesis is the average detection limit
[redacted] = study area with the highest chemical concentration when data are available for comparison

[a] ODEQ 1994.
[b] Tetra Tech 1996. One sample.
[c] Curtis 1994.
[d] Toxicity equivalency concentration (TEC) is based on the sum of dioxin/furan TEC values from the World Health Organization (WHO).

No historical whole-body carp data were identified for the WFWF reach; thus, comparisons to the current data could not be made (Table 7-3).

Upper Willamette River

Ten COPCs—mercury, aldrin, chlordane, dieldrin, heptachlor epoxide, Aroclor 1254, Aroclor 1260, PCB 105, PCB 126. and 2,3,7,8-TCDD—were analyzed in samples of carp fillet in the current study and in nine samples collected in the upper Willamette River during 1989–1990 (Table 7-2; Appendix E). Mercury, aldrin, and 2,3,7,8-TCDD were the only COPCs detected in the historical samples. The mercury concentration measured in carp fillet in the current study is higher by a factor of 1.6 than the historical average concentration, while the concentrations of aldrin and 2,3,7,8-TCDD are similar, within one standard deviation, to the historical average concentrations.

No historical whole-body carp data were identified for the upper Willamette River; thus, comparisons to the current data could not be made (Table 7-3; Appendix E).

Table 7-3. Comparison of average chemical concentrations (± standard deviation) measured in carp whole body from WFWF (current) to historical average concentrations from other comparison areas

		Carp Whole Body				
Chemical	Units	WFWF (current)	WFWF (historical)	UWR	LWR	LCR
Total Inorganic Arsenic	µg/kg	5.7 ± 2.4				
Mercury	mg/kg	0.13 ± 0.03				[redacted][a] 0.07 ± 0.10[b]
Aldrin	µg/kg	1.3 ±1.1				[redacted][a] nd (2.5)[b] nd (10)[c]
Chlordane	µg/kg	[redacted]				nd (3)[a] 16 ± 13[c]
DDE	µg/kg	[redacted]				42 ± 32[a] 84 ± 26[b] 110 ± 71[c] 40 ± 14[d]
Dieldrin	µg/kg	[redacted]				2.6 ± 1.7[a] nd (5)[b] nd (20)[c] 2.2 ± 1.6[d]
Heptachlor epoxide	µg/kg	[redacted]				nd (3)[a] nd (2.5)[b] nd (10)[c] 0.26 ± 0.20[d]
Aroclor 1254	µg/kg	75 ± 21				[redacted][a] 50 ± 20[b]
Aroclor 1260	µg/kg	[redacted]				50 ± 32[a] 28 ± 2.8[b]
PCB 105	µg/kg	2 ± 0.5				
PCB 118	µg/kg	7.8 ± 1.8				
PCB 126	µg/kg	0.015 ± 0.002				
PCB 156/157	µg/kg	1.1 ± 0.39				
1,2,3,7,8-PeCDD	ng/kg	1.1 ± 0.35				1.5 ± 0.5[a] 0.4 ± 0.2[b] [redacted][c] 0.3 ± 0.1[d]
2,3,7,8-TCDD	ng/kg	0.82 ± 0.29				1.6 ± 0.3[a] 0.4 ± 0.3[b] [redacted][c] 0.7 ± 0.4[d]
TEC[e]	ng/kg	4.6 ± 3.8				[redacted][a] 1.9 ± 0.6[b] 4.9 ± 7.2[c] 1.5 ± 0.8[d]

NOTE: nd = not detected; the value in parenthesis is the average detection limit
Shaded = study area with the highest chemical concentration when data are available for comparison

[a] Tetra Tech 1993.
[b] Tetra Tech 1994.
[c] Schuler 1994.
[d] Thomas 1997.
[e] Toxicity equivalency concentration (TEC) is based on the sum of dioxin/furan TEC values from the World Health Organization (WHO).

Lower Willamette River

Ten COPCs—aldrin, chlordane, DDE, dieldrin, heptachlor epoxide, Aroclor 1254, Aroclor 1260, PCB 105, PCB 126, and TEC—were analyzed in one composite fillet sample of carp in the current study and 13 samples collected in the lower Willamette River during 1988–1990 (Table 7-2; Appendix E). Five COPCs were detected in the historical study. The high variability of the historical data makes it difficult to make comparisons with the current study. With the exception of DDE, which appears to have a higher concentration in the current study by a factor of 4.2, the concentrations of other chemicals detected in both studies fall within one standard deviation of the historical average concentrations.

No historical whole-body carp data were identified for the lower Willamette River; thus, comparisons to the current data could not be made (Table 7-3; Appendix E).

Lower Columbia River

Eleven COPCs—inorganic arsenic, mercury, aldrin, DDE, dieldrin, heptachlor epoxide, , Aroclor 1254, and Aroclor 1260,1,2,3,7,8-PeCDD, 2,3,7,8-TCDD, TEC—were analyzed in one composite fillet sample of carp in the current study and one composite fillet sample collected in the lower Columbia River during 1994. Mercury, DDE, Aroclor 1260, and TEC were the only chemicals detected in both studies. Mercury and DDE concentrations measured in carp fillet in the current study were higher by factors of 1.7 and 1.3, respectively, than concentrations measured in 1994 from fish from the lower Columbia River. Aroclor 1260 and TEC concentrations showed the reverse trend, with carp fillet concentrations measured in the current study being lower by factors of 0.2 and 0.4, respectively, than the historical data from the lower Columbia River.

Four studies have reported measurements of chemicals concentrations in whole-body carp collected from the lower Columbia River during 1990-1994 (Tetra Tech 1993; Schuler 1994; Tetra Tech 1994; Thomas 1997). Eleven COPCs—mercury, aldrin, chlordane, DDE, dieldrin, heptachlor epoxide, Aroclor 1254, Aroclor 1260, 1,2,3,7,8-PeCDD, 2,3,7,8-TCDD, and TEC —were analyzed in whole-body samples of carp in the current study and 27 samples collected by these historical studies (Table 7-3; Appendix E). The average concentrations of chlordane, DDE, dieldrin, heptachlor epoxide, and Aroclor 1260 were higher in the current study than historical data from the lower Columbia River. However, given the variability around the average concentrations for the current and historical data, it is difficult to conclude that there are marked differences between these data sets.

7.2.3 Pikeminnow

Willamette Ferry-Willamette Falls Reach

Six COPCs—mercury, aldrin, chlordane, dieldrin, Aroclor 1254, and Aroclor 1260—were analyzed in one composite fillet sample of pikeminnow in the current study and 3-4 composite fillet samples collected in the WFWF reach during 1988-1989 (Appendix E). The concentrations of mercury, aldrin, Aroclor 1254, and Aroclor 1260 are higher by factors ranging from 1.5 to 3.0 in the current study than historical concentrations (Table 7-4). The historical concentrations of chlordane and dieldrin cannot be distinguished from current measurements given the historical detection limits and variability of measurements, respectively, reported for these chemicals.

No historical whole-body pikeminnow data were identified for the WFWF reach; thus, comparisons to the current data could not be made (Table 7-5; Appendix E).

Table 7-4. Comparison of average chemical concentrations (± standard deviation) measured in pikeminnow fillet from WFWF (current) to historical average concentrations from other comparison areas

		Pikeminnow Fillet				
Chemical	Units	WFWF (current)	WFWF[a] (historical)	UWR	LWR[a]	LCR[b]
Total inorganic arsenic	ug/kg	nd (3)				
Mercury	mg/kg	[illegible]	0.29 ± 0.13		0.49	0.42 ± 0.22
Aldrin	ug/kg	[illegible]	nd (4.3)		nd (3)	
Chlordane	ug/kg	[illegible]	nd (5.3)		nd (28)	
DDE	ug/kg	22				
Dieldrin	ug/kg	0.52	[illegible]		nd (2.5)	nd (2.5)
Heptachlor epoxide	ug/kg	nd (0.01)				
Aroclor 1254	ug/kg	[illegible]	5.3 ± 6.2		14 ± 1.8	
Aroclor 1260	ug/kg	[illegible]	nd (3.5)		nd (28)	
PCB 105	ug/kg	0.75				
PCB 118	ug/kg	2.5				
PCB 126	ug/kg	0.0067				
PCB 156/157	ug/kg	0.4				
1,2,3,7,8-PeCDD	ng/kg	0.18				[illegible]
2,3,7,8-TCDD	ng/kg	0.13				[illegible]
TEC (WHO)[c]	ng/kg	0.46				

NOTE: nd = not detected; the value in parenthesis is the average detection limit
Shaded = study area with the highest chemical concentration when data are available for comparison

[a] ODEQ 1994.
[b] USEPA 1992.
[c] Toxicity equivalency concentration (TEC) is based on the sum of dioxin/furan TEC values from the World Health Organization (WHO).

Table 7-5. Comparison of average chemical concentrations (± standard deviation) measured in pikeminnow whole body from WFWF (current) to historical average concentrations from other comparison areas

		PIKEMINNOW WHOLE BODY				
CHEMICAL	UNITS	WFWF (current)	WFWF (historical)	UWR[a]	LWR	LCR[b]
Total inorganic arsenic	µg/kg					
Mercury	mg/kg	[redacted]				
Aldrin	ug/kg	[redacted]		1.3 ± 0.9	nd (2.7)[a]	nd (10)
Chlordane	ug/kg	12 ± 4.6			nd (42)[a]	[redacted]
DDE	ug/kg	86 ± 38			18.7 ± 28.9[a]	[redacted]
Dieldrin	ug/kg	[redacted]			nd (3.3)[a]	nd (15)
Heptachlor epoxide	ug/kg	[redacted]			nd (3.3)[a]	nd (10)
Aroclor 1254	ug/kg	[redacted]			nd (25)[a]	
Aroclor 1260	ug/kg	47 ± 26			[redacted]	
PCB 105	ug/kg	[redacted]		nd (2)	2 ± 1.3[a]	
PCB 118	ug/kg	[redacted]				
PCB 126	ug/kg	[redacted]			2.7 ± 2.9[a]	
PCB 156/157	ug/kg	[redacted]				
1,2,3,7,8-PeCDD	ng/kg	0.56 ± 0.27				[redacted]
2,3,7,8-TCDD	ng/kg	0.37 ± 0.16				[redacted]
TEC (WHO)[c]	ng/kg	3.5 ± 4.0			3.4 ± 1.3[d]	[redacted]

NOTE: nd = not detected; the value in parenthesis is the average detection limit
[redacted] = study area with the highest chemical concentration when data are available for comparison

[a] ODEQ 1994.
[b] Schuler 1994.
[c] Toxicity equivalency concentration (TEC) is based on the sum of dioxin/furan TEC values from the World Health Organization (WHO).
[d] Curtis 1994.

Upper Willamette River

No historical fillet pikeminnow data were identified for the upper Willamette River; thus, comparisons to the current data could not be made (Table 7-4).

Two COPCs— aldrin and PCB 105—were measured in three composite whole-body pikeminnow samples collected in the current study and 12 whole-body pikeminnow samples collected in 1990 from the upper Willamette River (Table 7-5; Appendix E). The historical concentration of aldrin is similar to concentrations measured in the current study. PCB 105 was not detected in the 12 samples collected in 1990 in the upper Willamette River. The average PCB 105 concentration measured in the current study was 1.1 times higher than the historical average of the detection limits. Given the variability of measured concentrations of PCB 105, the current concentrations cannot be distinguished from the historical data.

Lower Willamette River

Six COPCs—mercury, aldrin, chlordane, dieldrin, Aroclor 1254, and Aroclor 1260—were measured in one composite fillet sample of pikeminnow in the current study and 1-3 fillet samples collected from the lower Willamette River during 1988–1989 (Table 7-4; Appendix E). Mercury and Aroclor 1254 were the only chemicals detected in the historical samples. The mercury concentrations measured in the current study was higher than the one historical measurement by a factor of 1.5. The Aroclor 1254 concentration measured in the current study was higher than the historical average concentration by a factor of 1.1.

Ten COPCs—aldrin, chlordane, DDE, dieldrin, heptachlor epoxide, Aroclor 1254, Aroclor 1260, PCB 105, and PCB 126, and TEC—were measured in the three whole-body pikeminnow samples collected in the current study and nine samples collected from the lower Willamette River during 1990 (Table 7-5; Appendix E). DDE, Aroclor 1260, PCB 105, PCB 126, and TEC were the only chemicals detected in 1990. Average concentrations of DDE and PCB126 in the current study were higher than the historical average concentrations by factors of 1.3 and 5.0, respectively. Average concentrations of PCB 105 and TEC in the current study were the same as historical averages, while average concentrations of Aroclor 1260 in the current study were lower by a factor of 0.4 than the historical average concentration in whole-body pikeminnow.

Lower Columbia River

Four COPCs—mercury, dieldrin, 1,2,3,7,8-PeCDD, and 2,3,7,8-TCDD—were measured in one composite fillet sample of pikeminnow in the current study and five fillet samples collected from the lower Columbia River during 1987 (Table 7-4; Appendix E). All of these chemicals except dieldrin were detected in the historical samples. Average mercury concentrations measured in the current study were higher than the average lower Columbia River fillet concentration by a factor of 1.7. Average concentrations of 1,2,3,7,8-PeCDD, and 2,3,7,8-TCDD in the current study were lower than historical average concentrations by factors of 0.26 and 0.08, respectively.

Eight COPCs—aldrin, chlordane, DDE, dieldrin, heptachlor epoxide, 1,2,3,7,8-PeCDD, 2,3,7,8-TCDD, and TEC—were measured in three whole-body pikeminnow samples collected in the current study and five whole-body samples collected from the lower Columbia River during 1990–1991 (Table 7-5; Appendix E). Aldrin, dieldrin, and heptachlor epoxide were not detected in the historical samples. Average concentrations of the other five chemicals in whole-body samples were lower in the current study than historical averages by factors ranging from 0.09 to 0.53. However, given the variability associated with the average concentrations for both the current and historical data, the current concentrations of these chemicals cannot be distinguished from the historical data.

Columbia River during 1990–1991 (Table 7-5; Appendix E). Aldrin, dieldrin, and heptachlor epoxide were not detected in the historical samples. Average concentrations of the other five chemicals in whole-body samples were lower in the current study than historical averages by factors ranging from 0.09 to 0.53. However, given the variability associated with the average concentrations for both the current and historical data, the current concentrations of these chemicals cannot be distinguished from the historical data.

7.2.4 Sucker

Willamette Ferry-Willamette Falls Reach

One COPC, aldrin, was analyzed in one composite fillet sample of sucker in the current study and a single fillet sample collected in the WFWF reach in 1989 (Table 7-6; Appendix E). Neither study detected this chemical.

No historical whole-body sucker data were identified for the WFWF reach; thus, comparisons to the current data could not be made (Table 7-7).

Table 7-6. Comparison of average chemical concentrations (± standard deviation) measured in sucker fillet from WFWF (current) to historical average concentrations from other comparison areas

		Sucker Fillet				
Chemical	Units	WFWF (current)	WFWF[a] (historical)	UWR	LWR[a]	LCR[b]
Total inorganic arsenic	µg/kg	4				[illegible]
Mercury	mg/kg	[illegible]				0.15 ± 0.026
Aldrin	µg/kg	nd (3.6)	nd (2)		nd (2)	nd (0.016)
Chlordane	µg/kg	nd (37.1)				
DDE	µg/kg	23				[illegible]
Dieldrin	µg/kg	[illegible]				nd (0.03)
Heptachlor epoxide	µg/kg	[illegible]				nd (0.02)
Aroclor 1254	µg/kg	nd (63)				nd (1.85)
Aroclor 1260	µg/kg	nd (46)				[illegible]
PCB 105	µg/kg	0.36				
PCB 118	µg/kg	1.2				
PCB 126	µg/kg	nd (0.0029)				
PCB 156/157	µg/kg	0.17				
1,2,3,7,8-PeCDD	ng/kg	0.06				nd (0.56)
2,3,7,8-TCDD	ng/kg	0.08				nd (0.38)
TEC (WHO)[c]	ng/kg	0.21				0.98 ± 0.47

NOTE: nd = not detected; the value in parenthesis is the average detection limit
Shaded = study area with the highest chemical concentration when data are available for comparison

[a] ODEQ 1994.
[b] Tetra Tech 1996.
[c] Toxicity equivalency concentration (TEC) is based on the sum of dioxin/furan TEC values from the World Health Organization (WHO).

Table 7-7. Comparison of average chemical concentrations (± standard deviation) measured in sucker whole body from WFWF (current) to historical average concentrations from other comparison areas

		Sucker Whole Body				
Chemical	Units	WFWF (current)	WFWF (historical)	UWR	LWR[a]	LCR
Total inorganic arsenic	µg/kg	19				
Mercury	mg/kg	0.12 ± 0.01				0.08 ± 0.03[b] [redacted]
Aldrin	µg/kg	0.96 ± 0.20				[redacted] nd (4.7)[c] nd (10)[d]
Chlordane	µg/kg	15.5 ± 5.2				nd (3)[b] [redacted]
DDE	µg/kg	76.3 ± 14.0			70.3	34 ± 16[b] [redacted]1[c] 92 ± 78[d] 53.2 ± 73[e]
Dieldrin	µg/kg	3.4			[redacted]	1.7 ± 0.7[b] nd (8.8)[c] nd (17)[d] 3.3 ± 1.9[e]
Heptachlor epoxide	µg/kg	0.28 ± 0.14			[redacted]	nd (3)[b] nd (2.7)[c] nd (10)[d] 0.34 ± 0.0[e]
Aroclor 1254	µg/kg	59 ± 8.3				130 ± 82[b] [redacted]
Aroclor 1260	µg/kg	[redacted]				31 ± 25[b] 39 ± 26[c]
PCB 105	µg/kg	1.667				
PCB 118	µg/kg	5.1				
PCB 126	µg/kg	0.013				
PCB 156/157	µg/kg	0.75				
1,2,3,7,8-PeCDD	ng/kg	0.43 ± 0.21			0.6	0.6 ± 0.2[b] 0.37 ± 0.16[c] [redacted] 0.32 ± 0.39[e]
2,3,7,8-TCDD	ng/kg	0.35			0.7	[redacted] 0.40 ± 0.26[c] 1.10 ± 0.58[d] 0.45 ± 0.07[e]
TEC (WHO)[e]	ng/kg	[redacted]			2	3.0 ± 0.88[b] 2.0 ± 0.71[c] 2.1 ± 1.0[d] 1.3 ± 0.8[e]

NOTE: nd = not detected; the value in parenthesis is the average detection limit
Shaded = study area with the highest chemical concentration when data are available for comparison

[a] Thomas 1997.
[b] Tetra Tech 1993.
[c] Tetra Tech 1994.
[d] Schuler 1994.
[e] Toxicity equivalency concentration (TEC) is based on the sum of dioxin/furan TEC values from the World Health Organization (WHO).

Upper Willamette River

No historical fillet or whole-body sucker data were identified for the upper Willamette River; thus, comparisons to the current data could not be made (Table 7-6; Table 7-7).

Lower Willamette River

One COPC, aldrin, was analyzed in one fillet sample of sucker in the current study and two fillet samples collected in the lower Willamette River during 1989 (Table 7-6; Appendix E). Neither study detected this chemical.

Six COPCs—DDE, dieldrin, heptachlor epoxide, 1,2,3,7,8-PeCDD, 2,3,7,8-TCDD, and TEC—were measured in two whole-body samples of sucker in the current study and one whole-body sample collected in the lower Willamette River in 1994 (Table 7-7; Appendix E). All of these chemicals were detected in the historical sample. Average concentrations of DDE and TEC in the current study were higher than the historical sample concentrations by factors of 1.1 and 1.5, respectively. Average concentrations of the other four chemicals in the current study were lower than historical concentrations by factors ranging from 0.12 to 0.72.

Lower Columbia River

Eleven COPCs—inorganic arsenic, mercury, aldrin, DDE, dieldrin, heptachlor epoxide, TEC, Aroclor 1254, Aroclor 1260, 1,2,3,7,8-PeCDD, and 2,3,7,8-TCDD—were analyzed in one fillet sample of sucker in the current study and nine fillet samples collected in the lower Columbia River during 1994 (Table 7-6; Appendix E). Aldrin, dieldrin, heptachlor epoxide, 1,2,3,7,8-PeCDD, Aroclor 1254, and 2,3,7,8-TCDD were not detected in the historical fillet samples. Average mercury concentration in the current study was higher than the historical average by a factor of 1.1. The average concentrations of inorganic arsenic, DDE, TEC, and Aroclor 1260 in the current study were lower than the historical average fillet concentrations by factors ranging from 0.17 to 0.63. Only current concentrations of DDE and TEC are outside one standard deviation of the historical average concentrations.

Four studies have reported measurements of chemicals concentrations in whole-body sucker collected from the lower Columbia River during 1990-1994 (Tetra Tech 1993; Schuler 1994; Tetra Tech 1994; Thomas 1997). Eleven COPCs—mercury, aldrin, chlordane, DDE, dieldrin, heptachlor epoxide, Aroclor 1254, Aroclor 1260, 1,2,3,7,8-PeCDD, 2,3,7,8-TCDD, and TEC—were analyzed in two whole-body sucker samples in the current study and 2-21 historical samples collected from the lower Columbia River (Table 7-7; Appendix E). Average concentrations of Aroclor 1260 and TEC were higher than historical average concentrations. However, given the variability associated with the average concentrations for the current and historical data, it is difficult to conclude that there are marked differences between these data sets. The average concentration of the other COPCs measured in the current study were within the range of average concentrations reported by the five other studies that have analyzed whole-body sucker samples.

7.3 CONCLUSIONS

Regional comparisons of average tissue concentrations show that 9 of the 16 COPCs are highest in at least one of the fish species analyzed in the present study. The average concentration of two chemicals measured in this study, mercury and Aroclor 1260, were highest in at least one tissue type for all four fish species. However, the ability to make historical comparisons within the WFWF reach is limited by the small amount of data that has been collected.

7.3.1 Willamette Ferry – Willamette Falls Reach

Two composite samples of bass fillet, 1 composite sample of carp fillet, 1 composite sample of pikeminnow fillet, and 1 composite sample of sucker fillet were analyzed in the current study, and average concentrations were compared to historical data from 1 sample of bass fillet, 9 samples of carp fillet, 3 to 4 samples of pikeminnow fillet, and 1 sample of sucker fillet from the WFWF reach. Average concentrations of three COPCs—mercury, Aroclor 1254, and Aroclor 1260—were higher in fillet samples of bass than concentrations collected historically in the same section of the Willamette River. Average concentrations of aldrin and these same three COPCs were higher in fillet samples of pikeminnow in the current study than historical concentrations. No other fish species or sample types had concentrations of any of the 16 COPCs that were higher in the current study than historical concentrations in the same region.

7.3.2 Upper Willamette River

One composite sample of carp fillet and 3 composite samples of pikeminnow whole body were analyzed in the current study, and average concentrations were compared to historical data from 9 samples of carp fillet and 12 samples of pikeminnow whole body from the upper Willamette River. Only one COPC—mercury—had average concentrations in the current study higher than historical average concentrations in carp fillet samples.

7.3.3 Lower Willamette River

One composite sample of bass fillet, 1 composite sample of pikeminnow fillet, 3 composite samples of pikeminnow whole body, 1 composite sample of sucker fillet, and 2 composite samples of sucker whole body were analyzed in the current study and average concentrations were compared to 13 samples of carp fillet, 1 to 3 samples of pikeminnow fillet, 9 samples of pikeminnow whole body, 2 samples of sucker fillet, and sample of sucker whole body from the lower Willamette River. Average concentrations of one COPC—DDE—were higher in the current study than in historical studies in the lower Willamette River for fillet samples of carp and whole-body samples of pikeminnow. One COPC—PCB 126—had higher average concentrations in whole-body samples of pikeminnow from the current studies compared to historical concentrations. Two COPCs—mercury and Aroclor 1254—had average concentrations in pikeminnow fillet samples that were higher in the current study than in historical lower Willamette River studies.

7.3.4 Lower Columbia River

One composite sample of bass fillet, 1 composite sample of carp fillet, 5 composite samples of carp whole body, 1 composite sample of pikeminnow fillet, 3 composite samples of pikeminnow whole body, 1 composite sample of sucker fillet, and 2 composite samples of sucker whole body were analyzed in the current study, and average concentrations were compared to 1 sample of bass fillet, 1 sample of carp fillet, 27 samples of carp whole body, 5 samples of pikeminnow fillet, 5 samples of pikeminnow whole body, 9 samples of sucker fillet, and 2 to 21 samples of sucker whole body from the lower Columbia River. Two COPCs—mercury and DDE—had higher average concentrations in the current study compared to historical data from the lower Columbia River in fillet samples of carp. Five COPCs—chlordane, DDE, dieldrin, heptachlor epoxide, and Aroclor 1260—had higher average concentrations in the current study compared to historical concentrations in the lower Columbia River in whole-body samples of carp. One COPC—mercury—had higher average concentrations in samples of pikeminnow whole body and sucker fillets in the current study compared to historical data from the lower Columbia River.

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APPENDIX A

Descriptive Data for Fish Samples

Table A-1. Fork length (mm), field wet weight (g), collection segment, and collection date of individual fish composited for analysis

Composite Number	Species	Sample Type	No. Fish per Composite	Specimen Number	Fork Length (mm)	Weight (g)	Collection Segment
1	Largescale sucker	F	8	11	388	635	1
				16	380	590	1
				21	380	544	1
				22	375	590	1
				24	370	726	1
				39	375	544	1
				42	390	680	1
				48	380	680	1
2	Largescale sucker	WB - F	8	11	388	635	1
				16	380	590	1
				21	380	544	1
				22	375	590	1
				24	370	726	1
				39	375	544	1
				42	390	680	1
				48	380	680	1
3	Carp	WB	5	72	570	3719	2
				73	540	3221	2
				74	490	2631	2
				275	530	2495	2
				278	525	2585	2
4	Carp	WB	5	71	610	4128	2
				109	615	5670	2
				271	590	3856	2
				276	605	5352	2
				279	575	3765	2
5	Carp	WB	5	272	625	3266	2
				273	635	4944	2
				274	715	6713	2
				277	660	6713	2
				280	655	4717	2
6	Smallmouth bass	F	5	57	210	181	2
				58	320	499	2
				70	300	544	2
				94	160	91	2
				108	160	136	2
7	Smallmouth bass	F	5	12	202	136	1
				237	260	272	5
				268	260	227	3
				269	160	91	3
				270	320	408	3
8	Carp	F	5	142	565	3765	3
				144	540	2722	3
				159	540	3447	3
				161	570	3901	3
				162	570	4309	3
9	Carp	WB - F	5	142	565	3765	3
				144	540	2722	3
				159	540	3447	3
				161	570	3901	3
				162	570	4309	3

Table A-1. Fork length (mm), field wet weight (g), collection segment, and collection date of individual fish composited for analysis

Composite Number	Species	Sample Type	No. Fish per Composite	Specimen Number	Fork Length (mm)	Weight (g)	Collection Segment
10	Northern pikeminnow	F	8	113	360	590	3
				136	340	363	3
				138	290	318	3
				139	260	227	3
				153	315	408	3
				154	335	454	3
				156	340	544	3
				157	290	227	3
11	Northern pikeminnow	WB - F	8	113	360	590	3
				136	340	363	3
				138	290	318	3
				139	260	227	3
				153	315	408	3
				154	335	454	3
				156	340	544	3
				157	290	227	3
12	Largescale sucker	WB	8	177	385	680	4
				178	380	771	4
				180	400	726	4
				183	390	680	4
				184	330	318	4
				185	330	454	4
				211	375	544	4
				214	365	635	4
13	Northern pikeminnow	WB	8	163	280	227	4
				168	335	454	4
				171	280	227	4
				193	325	408	4
				197	305	272	4
				199	275	227	4
				200	300	181	4
				220	335	544	4
14	Carp	WB	5	238	550	2812	5
				244	600	4218	5
				245	570	3538	5
				263	455	1724	5
				264	590	4309	5
15	Northern pikeminnow	WB	8	232	190	45	5
				233	190	45	5
				241	190	91	5
				246	200	45	5
				256	185	91	5
				259	190	136	5
				260	185	91	5
				261	180	91	5

NOTE: F - fillet without skin
WB - whole body
WB - F - whole body minus fillets from both sides of the fish

APPENDIX B

Chemistry Data for Fish Composite Samples

Table B-1. Trace metal concentrations (mg/kg wet weight) in composite fish samples collected from the Willamette River

		Composite 1		Composite 2		Composite 3		Composite 4		Composite 5		Composite 6	
		Species	Sucker	**Species**	Sucker	**Species**	Carp	**Species**	Carp	**Species**	Carp	**Species**	Bass
		Sample Type	Fillet	**Sample Type**	WB-fillet	**Sample Type**	WB	**Sample Type**	WB	**Sample Type**	WB	**Sample Type**	Fillet
Analyte (mg/kg)	**CAS #**	**Concentration**	**Qualifier**	**Concentration**	**Qualifier**	**Concentration**	**Qualifier**	**Concentration**	**Qualifier**	**Concentration**	**Qualifier**	**Concentration**	**Qualifier**
Ag	7440-22-4	0.02		0.05		0.03		0.02		0.01		0.01	U
As	7440-38-2	0.08		0.17		0.16		0.13		0.15		0.11	
As - Tl	N/A	0.004		0.036		0.007		0.009		0.005		0.003	U
Be	7440-41-7	0.001	U	0.006		0.003		0.002		0.001	U	0.001	U
Cd	7440-43-9	0.01	U	0.01		0.01		0.01		0.01		0.01	U
Cr	7440-47-3	0.14		0.62		0.34		0.54		0.64		0.19	
Cu	7440-50-8	0.39		2.86		2.77		1.50		1.29		0.68	
Hg	7439-97-6	0.163		0.075		0.096		0.104		0.162		0.334	
Ni	7440-02-0	0.02		0.51		0.31		0.07		0.13		0.10	
Pb	7439-92-1	0.005	U	0.141		0.035		0.049		0.031		0.005	U
Sb	7440-36-0	0.001	U	0.001		0.001		0.001		0.001	U	0.001	U
Tl	7440-28-0	0.002	U	0.002	U	0.002	U	0.002	U	0.002	U	0.002	U
Zn	7440-66-6	8.31		17.5		74.9		98.8		102		6.22	

		Composite 7		Composite 8		Composite 9		Composite 10		Composite 11		Composite 12	
		Species	Bass	**Species**	Carp	**Species**	Carp	**Species**	Pikeminnow	**Species**	Pikeminnow	**Species**	Sucker
		Sample Type	Fillet	**Sample Type**	Fillet	**Sample Type**	WB-fillet	**Sample Type**	Fillet	**Sample Type**	WB-fillet	**Sample Type**	WB
Analyte (mg/kg)	**CAS #**	**Concentration**	**Qualifier**	**Concentration**	**Qualifier**	**Concentration**	**Qualifier**	**Concentration**	**Qualifier**	**Concentration**	**Qualifier**	**Concentration**	**Qualifier**
Ag	7440-22-4	0.01	U	0.01	U	0.03		0.01	U	0.01	U	0.01	U
As	7440-38-2	0.08		0.12		0.17		0.05	U	0.05	U	0.12	
As - Tl	N/A	0.005		0.003	U	0.006		0.003	U	0.003	U	0.016	
Be	7440-41-7	0.001	U	0.001	U	0.001	U	0.002		0.001	U	0.010	
Cd	7440-43-9	0.01	U	0.01	U	0.02		0.01	U	0.01	U	0.01	
Cr	7440-47-3	0.19		0.23		0.51		0.18		0.17		0.32	
Cu	7440-50-8	0.95		0.67		1.81		0.49		0.61		1.78	
Hg	7439-97-6	0.416		0.247		0.075		0.717		0.337		0.121	
Ni	7440-02-0	0.13		0.01	U	0.01	U	0.04		0.01	U	0.31	
Pb	7439-92-1	0.005	U	0.005	U	0.033		0.005	U	0.005	U	0.037	
Sb	7440-36-0	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U
Tl	7440-28-0	0.002	U	0.002	U	0.002	U	0.002	U	0.002	U	0.002	U
Zn	7440-66-6	8.99		29.7		114		6.88		12.7		11.3	

Table B-1. Trace metal concentrations (mg/kg wet weight) in composite fish samples collected from the Willamette River

		Composite 13		Composite 14		Composite 15	
		Species	Pikeminnow	Species	Carp	Species	Pikeminnow
		Sample Type	WB	Sample Type	WB	Sample Type	WB
Analyte (mg/kg)	CAS #	Concentration	Qualifier	Concentration	Qualifier	Concentration	Qualifier
Ag	7440-22-4	0.01	U	0.02		0.01	U
As	7440-38-2	0.05	U	0.15		0.05	U
As - TI	N/A	0.003	U	0.003		0.003	U
Be	7440-41-7	0.001	U	0.002		0.001	U
Cd	7440-43-9	0.01	U	0.04		0.02	
Cr	7440-47-3	0.18		0.49		0.18	
Cu	7440-50-8	0.74		1.55		1.10	
Hg	7439-97-6	0.483		0.149		0.057	
Ni	7440-02-0	0.01	U	0.01	U	0.01	U
Pb	7439-92-1	0.006		0.014		0.007	
Sb	7440-36-0	0.001	U	0.001	U	0.001	U
Tl	7440-28-0	0.002	U	0.002	U	0.002	U
Zn	7440-66-6	12.1		74.9		18.2	

NOTE. As - TI - total inorganic arsenic
U - non-detected

Table B-2. Pesticide concentrations (ng/g) in composite fish samples collected from the Willamette River

					Hexachlorobenzene CAS 118-74-1 Concentration (ng/g)			alpha HCH CAS 319-84-6 Concentration (ng/g)			beta HCH CAS 319-85-7 Concentration (ng/g)			gamma HCH CAS 58-89-9 Concentration (ng/g)			Heptachlor CAS 76-44-8 Concentration (ng/g)		
Species	Sample Type	Composite Sample	Collection Location[a]	Percent Lipid	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier
Bass	Fillet	6	34 4 - 43.0	1.4	0.67	47.86		0.11	7.86	U	0.15	10.71	U	0.82	58.57		0.23	16.43	U
Bass	Fillet	7	43 0 - 71.9	1.3	0.9	69.23		0.13	10.00	U	0.19	14.62	U	0.79	60.77	J	0.31	23.85	U
Carp	WB	3	43.0 - 71.9	7.2	5.3	73.61		0.16	2.22	U	0.23	3.19	U	1.1	15.28	J	0.14	1.94	U
Carp	WB	3	43.0 - 71 9	7.2	5.9	81.94		0.41	5.69	U	0.57	7.92	U	1.6	22.22	J	0.2	2.78	U
Carp	WB	4	34.4 - 43.0	5.1	4.1	80.39		0.13	2.55	U	0.18	3.53	U	0.85	16.67		0.17	3.33	U
Carp	WB	5	34.4 - 43.0	8.5	7.6	89.41		0.19	2.24		0.16	1.88	J	1.2	14.12	J	0.25	2.94	U
Carp	Fillet	8	43 0 - 50 0	3.5	2.6	74.29		0.11	3.14	U	0.15	4.29	U	0.89	25.43	J	0.26	7.43	U
Carp	WB-fillet	9	43 0 - 50.0	7.6	5.1	67.11		0.75	9.87	J	0.38	5.00	J	1.6	21.05	J	0.22	2.89	U
Carp	WB-fillet	9	43.0 - 50 0	7.6	5.6	73.68		0.31	4.08	J	0.22	2.89	J	1.8	23.68		0.10	1.32	U
Carp	WB	14	56 5 - 71.9	6.1	4.1	67.21		0.12	1.97	J	0.13	2.13	U	0.82	13.44		0.14	2.30	U
Pikeminnow	Fillet	10	43.0 - 50 0	1.8	1.0	55.56		0.54	30.00	U	0.69	38.33	U	1.1	61.11	J	0.24	13.33	U
Pikeminnow	WB-fillet	11	43 0 - 50.0	8.1	4.7	58.02		0.54	6.67	J	0.13	1.60	J	1.0	12.35	J	0.09	1.11	U
Pikeminnow	WB	13	50.0 - 56.5	5.8	3.2	55.17		0.32	5.52	U	0.44	7.59	U	1.1	18.97	J	0.27	4.66	U
Pikeminnow	WB	15	56.5 - 71.9	3.6	2.3	63.89		0.04	1.11	U	0.06	1.67	U	0.64	17.78	J	0.17	4.72	U
Sucker	Fillet	1	26 5 - 34.4	2.0	2.0	100.00	U	6.2	310.00	U	8.7	435.00	U	5.0	250.00	U	17	850.00	U
Sucker	WB-fillet	2	26.5 - 34.4	9.9	4.9	49.49		1.4	14.14	J	0.58	5.86	U	1.9	19.19	J	0.37	3.74	U
Sucker	WB	12	50 0 - 56 5	7.9	4.4	55.70		0 83	10.51	J	0.27	3.42	J	0.98	12.41	J	0.16	2.03	U

					Aldrin CAS 309-00-2 Concentration (ng/g)			Oxychlordane CAS 27304-13-8* Concentration (ng/g)			trans-Chlordane CAS 57-74-9+ 5103-74-2* Concentration (ng/g)			cis-Chlordane CAS 57-74-9+ 5103-71-9* Concentration (ng/g)			o,p'-DDE CAS 3424-82-6 Concentration (ng/g)		
Species	Sample Type	Composite Sample	Collection Location[a]	Percent Lipid	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier
Bass	Fillet	6	34 4 - 43.0	1.4	0.08	5.71	U	0.79	56.43	U	0.09	6.43		0.22	15.71		0.09	6.43	
Bass	Fillet	7	43 0 - 71.9	1.3	0.09	6.92	U	0.59	45.38	U	0.13	10.00		0.21	16.15		0.08	6.15	
Carp	WB	3	43.0 - 71.9	7.2	0.3	4.17	U	1.8	25.00	U	1.9	26.39		4.0	55.56		0.58	8.06	
Carp	WB	3	43.0 - 71.9	7.2	0.31	4.31	U	1.4	19.44	U	2.2	30.56		4.6	63.89		0.67	9.31	
Carp	WB	4	34 4 - 43.0	5.1	0.11	2.16	J	1.3	25.49	J	2.3	45.10		5.5	107.84		0.48	9.41	
Carp	WB	5	34 4 - 43.0	8.5	1.9	22.35	J	4.3	50.59	J	2.3	27.06		4.5	52.94		0.66	7.76	
Carp	Fillet	8	43.0 - 50.0	3.5	0.08	2.29	J	0.86	24.57	J	0.88	25.14		2.2	62.86		0.18	5.14	
Carp	WB-fillet	9	43 0 - 50.0	7.6	5.2	68.42	J	2.2	28.95	J	1.8	23.68		4.2	55.26		0.50	6.58	
Carp	WB-fillet	9	43.0 - 50.0	7.6	2.4	31.58	J	3.2	42.11	J	2.0	26.32		4.9	64.47		0.54	7.11	
Carp	WB	14	56.5 - 71.9	6.1	1.9	31.15	J	2.2	36.07	J	2.4	39.34		5.7	93.44		0.34	5.57	
Pikeminnow	Fillet	10	43.0 - 50.0	1.8	6.5	361.11	J	2.9	161.11	U	0.22	12.22		0.45	25.00		0.16	8.89	
Pikeminnow	WB-fillet	11	43.0 - 50.0	8.1	2.4	29.63	J	4.0	49.38	J	1.1	13.58		2.5	30.86		0.72	8.89	
Pikeminnow	WB	13	50.0 - 56.5	5.8	0.23	3.97	U	1.8	31.03	J	0.91	15.69		2.1	36.21		0.63	10.86	
Pikeminnow	WB	15	56.5 - 71.9	3.6	0.03	0.83	U	0.89	24.72	J	0.43	11.94		0.89	24.72		0.22	6.11	
Sucker	Fillet	1	26.5 - 34.4	2.0	3.6	180.00	U	27	1350.00	U	2.7	135.00	U	2.3	115.00	U	3.2	160.00	U
Sucker	WB-fillet	2	26.5 - 34.4	9.9	0.26	2.63	U	3.0	30.30	J	2.2	22.22		4.4	44.44		0.79	7.98	
Sucker	WB	12	50.0 - 56.5	7.9	1.1	13.92	J	1.3	16.46		1.1	13.92		2.5	31.65		0.40	5.06	

Table B-2. Pesticide concentrations (ng/g) in composite fish samples collected from the Willamette River

					p,p'-DDE CAS 72-55-9			trans-Nonachlor CAS 3734-49-4+ 39765-80-5*			cis-Nonachlor CAS 5103-73-1+			o,p'-DDD CAS 53-19-0			p,p'-DDD CAS 72-54-8		
					Concentration (ng/g)			Concentration (ng/g)			Concentration (ng/g)			Concentration (ng/g)			Concentration (ng/g)		
Species	Sample Type	Composite Sample	Collection Location*	Percent Lipid	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier
Bass	Fillet	6	34.4 - 43.0	1.4	18	1285.71		1.1	78.57		0.36	25.71		0.14	10.00		1.3	92.86	
Bass	Fillet	7	43.0 - 71 9	1.3	14	1076.92		1.1	84 62		0.3	23.08		0.12	9.23		1.0	76.92	
Carp	WB	3	43 0 - 71.9	7.2	210	2916.67		6.1	84.72		2.5	34.72		2.2	30.56		16	222.22	
Carp	WB	3	43.0 - 71.9	7.2	230	3194.44		7.9	109.72		3.2	44.44		2.5	34.72		17	236.11	
Carp	WB	4	34 4 - 43 0	5.1	140	2745.10		8.8	172.55		3.0	58.82		1.8	35.29		15	294.12	
Carp	WB	5	34.4 - 43 0	8.5	160	1882.35	EJ	8.6	101.18		3.4	40.00		2.4	28.24		18	211.76	
Carp	Fillet	8	43 0 - 50 0	3.5	170	4857.14	EJ	3 8	108.57		1.7	48.57		0.81	23.14		9.7	277.14	
Carp	WB-fillet	9	43 0 - 50 0	7 6	380	5000.00	EJ	9.7	127.63		3.7	48.68		1.8	23.68		17	223.68	
Carp	WB-fillet	9	43.0 - 50.0	7 6	380	5000.00	EJ	11	144.74		4.3	56.58		2.0	26.32		20	263.16	
Carp	WB	14	56.5 - 71.9	6.1	120	1967.21		11	180.33		4.2	68.85		2.0	32.79		19	311.48	
Pikeminnow	Fillet	10	43 0 - 50.0	1.8	22	1222.22		1.5	83.33		0.45	25.00		0.24	13.33	J	2.5	138.89	
Pikeminnow	WB-fillet	11	43.0 - 50.0	8.1	140	1728.40		10	123.46		2.8	34.57		1.2	14.81		13	160.49	
Pikeminnow	WB	13	50.0 - 56.5	5.8	120	2068.97		8.0	137.93		2.2	37.93		0.81	13.97		9.0	155.17	
Pikeminnow	WB	15	56 5 - 71.9	3.6	45	1250.00		3.4	94.44		0.87	24.17		0.29	8.06		2.8	77.78	
Sucker	Fillet	1	26.5 - 34 4	2.0	21	1050 00		3.0	150.00	U	2.1	105.00	U	1.2	60.00	U	3.8	190.00	
Sucker	WB-fillet	2	26.5 - 34 4	9.9	130	1313.13		7.2	72.73		2.8	28.28		3.7	37.37		31	313.13	
Sucker	WB	12	50.0 - 56.5	7.9	66	835.44		5.1	64.56		1.8	22.78		1.1	13.92		7.6	96.20	

				Chemical CAS#	o,p'-DDT 789-02-6*			p,p'-DDT 50-29-3+			Mirex 2385-85-5			Heptachlor Epoxide 1024-57-3			alpha-Endosulfan (I) 959-98-8		
					Concentration (ng/g)			Concentration (ng/g)			Concentration (ng/g)			Concentration (ng/g)			Concentration (ng/g)		
Species	Sample Type	Composite Sample	Collection Location*	Percent Lipid	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier
Bass	Fillet	6	34.4 - 43.0	1.4	0.21	15.00		1.4	100.00		0.04	2.86		0.01	0.71	U	0.01	0.71	U
Bass	Fillet	7	43.0 - 71.9	1.3	0.22	16.92	J	1.5	115.38		0.05	3.85		0.007	0.54	U	0.01	0.77	U
Carp	WB	3	43.0 - 71.9	7.2	1.6	22.22	J	1.6	22.22		0.13	1.81	J	0.20	2.78		0.008	0.11	U
Carp	WB	3	43.0 - 71.9	7.2	2.0	27.78		1.5	20.83		0.12	1.67	J	0.26	3.61		0.007	0.10	U
Carp	WB	4	34.4 - 43.0	5.1	1.8	35.29	J	1.7	33.33		0.18	3.53	J	0.18	3.53		0.01	0.20	U
Carp	WB	5	34 4 - 43.0	8.5	1.7	20.00	J	2 2	25.88	J	0.33	3.88	J	0.39	4.59		0.74	8.71	
Carp	Fillet	8	43 0 - 50.0	3.5	0.92	26.29	J	0.92	26.29		0.10	2.86	J	0.17	4.86		0.03	0.86	U
Carp	WB-fillet	9	43 0 - 50.0	7 6	2.2	28.95	J	2.8	36.84	J	0.21	2.76	J	0.40	5.26		0.66	8.68	
Carp	WB-fillet	9	43 0 - 50.0	7.6	2.2	28.95	J	2.1	27.63		0.25	3.29	J	0.34	4.47		0.67	8.82	
Carp	WB	14	56 5 - 71.9	6.1	2.0	32.79	J	3.5	57.38		0.14	2.30		0.44	7.21		0.01	0.16	U
Pikeminnow	Fillet	10	43 0 - 50.0	1.8	0 32	17.78		0.28	15.56	J	0.09	5.00	J	0.01	0.56	U	0.02	1.11	U
Pikeminnow	WB-fillet	11	43 0 - 50.0	8.1	1.9	23.46	J	0.53	6.54		0.29	3.58	J	0.27	3.33		0.01	0.12	U
Pikeminnow	WB	13	50 0 - 56 5	5.8	2.1	36.21	J	0.35	6.03		0.25	4.31		0.15	2.59		0.01	0.17	U
Pikeminnow	WB	15	56.5 - 71.9	3.6	0 85	23.61	J	0.12	3.33		0.07	1.94		0.03	0.83	U	0.04	1.11	U
Sucker	Fillet	1	26.5 - 34.4	2.0	2.5	125.00	U	3.1	155.00	U	1.6	80.00	U	0.03	1.50		0.02	1.00	U
Sucker	WB-fillet	2	26 5 - 34.4	9.9	3.5	35.35	J	21	212.12		0.18	1.82	J	0.28	2.83		0.02	0.20	U
Sucker	WB	12	50.0 - 56.5	7.9	1.7	21.52		15	189.87		0.11	1.39	J	0.38	4.81		0.01	0.13	U

Table B-2. Pesticide concentrations (ng/g) in composite fish samples collected from the Willamette River

					Dieldrin CAS 60-57-1			Endrin CAS 72-20-8			Methoxychlor CAS 72-43-5		
					Concentration (ng/g)			Concentration (ng/g)			Concentration (ng/g)		
Species	Sample Type	Composite Sample	Collection Location[a] (RM)	Percent Lipid	Wet Weight	Lipid Normalized	Data Qualifier	Wet Weight	Lipid Normalized	Data Qualifier	Wet Weight	Lipid Normalized	Data Qualifier
Bass	Fillet	6	34.4 - 43.0	1.4	0.23	16.43		0.02	1.43	U	0.03	2.14	U
Bass	Fillet	7	43.0 - 71.9	1.3	0.24	18.46		0.01	0.77	U	0.02	1.54	U
Carp	WB	3	43 0 - 71.9	7.2	3.0	41.67		0.02	0.28		0.02	0.28	U
Carp	WB	3	43.0 - 71.9	7.2	3.5	48.61		0.03	0.42		0.02	0.28	U
Carp	WB	4	34.4 - 43.0	5.1	1.9	37.25		0.02	0.39	U	0.03	0.59	U
Carp	WB	5	34.4 - 43.0	8.5	5.6	65.88		0.06	0.71	U	0.14	1.65	U
Carp	Fillet	8	43.0 - 50.0	3.5	1.8	51.43		0.05	1.43	U	0.13	3.71	U
Carp	WB-fillet	9	43.0 - 50 0	7.6	4.4	57.89		0.05	0.66	U	0.12	1.58	U
Carp	WB-fillet	9	43 0 - 50.0	7 6	4.2	55.26		0.03	0.39	U	0.07	0.92	U
Carp	WB	14	56 5 - 71.9	6.1	4.4	72.13		0.03	0.49	U	0.64	10.49	
Pikeminnow	Fillet	10	43 0 - 50.0	1.8	0.52	28.89		0.03	1.67	U	0.06	3.33	U
Pikeminnow	WB-fillet	11	43.0 - 50.0	8.1	3 2	39.51		0.03	0.37	U	0.27	3.33	
Pikeminnow	WB	13	50.0 - 56.5	5.8	1.9	32.76		0.02	0.34	U	0.03	0.52	U
Pikeminnow	WB	15	56.5 - 71.9	3.6	0.86	23.89		0.07	1.94	U	0.15	4.17	U
Sucker	Fillet	1	26.5 - 34.4	2.0	0 42	21.00		0.02	1.00	U	0.02	1.00	U
Sucker	WB-fillet	2	26.5 - 34.4	9.9	2.8	28.28		0.03	0.30	U	0.05	0.51	U
Sucker	WB	12	50 0 - 58.5	7.9	5.0	63.29		0.03	0.38	U	0.06	0.76	U

NOTE: CAS # - Chemical Abstracts Services
U - undetected
WB - whole body
* - USEPA Environmental Monitoring Methods Index (EMMI) EPA#821-B-92-001
+'- http://webbook.nist.gov/chemistry/cas-ser.htm
a - average of two percent lipid duplicates
J - Value should be considered an estimate
E - concentration exceeds linear calibration range

[a] Segment 4 terminated at mouth of Yamhill River prior to RM 50 due to dredging activities in main channe

Table B-3. PAH concentrations (ng/g) in composite fish samples collected from the Willamette River

				Chemical CAS#	Naphthalene 91-20-3			Acenaphthylene 208-96-8			Acenaphthene 83-32-9			Fluorene 86-73-7			Phenanthrene 85-01-8		
					Concentration (ng/g)			Concentration (ng/g			Concentration (ng/g			Concentration (ng/g			Concentration (ng/g		
Species	Sample Type	Composite Sample	Collection Location	Percent Lipid	Wet Weight	Lipid Normalize	Qualifier	Wet Weight	Lipid Normalize	Qualifier	Wet Weight	Lipid Normalize	Qualifier	Wet Weight	Lipid Normalize	Qualifier	Wet Weight	Lipid Normalize	Qualifier
Bass	Fillet	6	34.4 - 43.0	1.4	NQ	NQ		0.76	54.3	J	0.22	15.7		0.62	44.3	U	1.1	78.6	
Bass	Fillet	7	43.0 - 71.9	1.3	11	846.2	J	1.4	107.7	UJ	1.5	115.4	UJ	1.5	115.4	UJ	2.2	169.2	J
Carp	WB	3	43.0 - 71.9	7.2	9.6	133.3		1.1	15.3		1.1	15.3		1.2	16.7		2.3	31.9	J
Carp	WB	4	34.4 - 43.0	5.1	9.2	180.4	J	0.94	18.4		1.1	21.6		1.0	19.6		1.9	37.3	J
Carp	WB	5	34.4 - 43.0	8.5	17	200.0	J	0.87	10.2	J	2.6	30.6	J	1.4	16.5	J	3.4	40.0	J
Carp	Fillet	8	43 0 - 50.0	3.5	13	371.4	J	1.8	51.4	UJ	1.9	54.3	UJ	1.9	54.3	UJ	1.9	54.3	J
Carp	Fillet	8	43.0 - 50.0	3.5	12	342.9	J	1.4	40.0	UJ	1.5	42.9	UJ	1.5	42.9	UJ	1.7	48.6	J
Carp	WB-fillet	9	43.0 - 50.0	7.6 [a]	12	157.9	J	0.70	9.2	UJ	1.2	15.8	J	0.72	9.5	UJ	1.7	22.4	J
Carp	WB	14	56.5 - 71.9	6.1	7.4	121.3	J	1.0	16.4	J	3.6	59.0	J	1.5	24.6	J	1.7	27.9	J
Pikeminnow	Fillet	10	43.0 - 50.0	1.8	9.9	550.0	J	0.98	54.4	UJ	1.0	55.6	UJ	1.0	55.6	UJ	1.6	88.9	J
Pikeminnow	WB-fillet	11	43.0 - 50.0	8.1	5.1	63.0	J	0.82	10.1		1.6	19.8	J	2.3	28.4		2.3	28.4	
Pikeminnow	WB	13	50.0 - 56.5	5.8	3.9	67.2	J	0.46	7.9	J	1.7	29.3	J	1.8	31.0	J	1.8	31.0	J
Pikeminnow	WB	15	56.5 - 71.9	3.6	4.1	113.9	J	0.52	14.4	J	2.2	61.1	J	1.2	33.3	J	1.2	33.3	J
Pikeminnow	WB	15	56.5 - 71 9	3.6	4.0	111.1	J	0.56	15.6	J	2.4	66.7	J	1.3	36.1	J	1.4	38.9	J
Sucker	Fillet	1	26.5 - 34.4	2.0	5.2	260.0		0.64	32.0		0.21	10.5		0.51	25.5		0.33	16.5	J
Sucker	Fillet	1	26.5 - 34.4	2.0	NQ	NQ		0.53	26.5		0.67	33.5	U	0.62	31.0		0.38	19.0	J
Sucker	WB-fillet	2	26 5 - 34.4	9.9	10	101.0		1.8	18.2		0.75	7.6		2.4	24.2		6.3	63.6	
Sucker	WB	12	50 0 - 56.5	7.9	4.4	55.7	J	0.60	7.6	J	9.7	122.8	J	2.5	31.6	J	2.6	32.9	J

				Chemical CAS#	Anthracene 120-12-7			Fluoranthene 206-44-0			Pyrene 129-00-0			Benz[a]anthracene 56-55-3			Chrysene[b] 218-01-9		
					Concentration (ng/g)			Concentration (ng/g			Concentration (ng/g			Concentration (ng/g			Concentration (ng/g		
Species	Sample Type	Composite Sample	Collection Location	Percent Lipid	Wet Weight	Lipid Normalize	Qualifier	Wet Weight	Lipid Normalize	Qualifier	Wet Weight	Lipid Normalize	Qualifier	Wet Weight	Lipid Normalize	Qualifier	Wet Weight	Lipid Normalize	Qualifier
Bass	Fillet	6	34.4 - 43.0	1.4	0.23	16.4	U	0.31	22.1		0.20	14.3		0.17	12.1	U	0.15	10.7	U
Bass	Fillet	7	43.0 - 71.9	1.3	0.71	54.6	UJ	0.54	41.5	J	0.33	25.4	J	0.20	15.4	UJ	0.21	16.2	UJ
Carp	WB	3	43.0 - 71 9	7.2	0.83	11.5	J	3.8	52.8		5.6	77.8		2.7	37.5		3.0	41.7	
Carp	WB	4	34 4 - 43.0	5.1	0.41	8.0	U	0.81	15.9	J	0.87	17.1	J	0.36	7.1	U	0.35	6.9	J
Carp	WB	5	34.4 - 43.0	8.5	0.72	8.5	UJ	0.89	10.5	UJ	1.4	16.5	J	0.59	6.9	UJ	0.61	7.2	UJ
Carp	Fillet	8	43.0 - 50 0	3.5	0.86	24.6	UJ	0.56	16.0	UJ	0.62	17.7	J	0.57	16.3	UJ	0.59	16.9	UJ
Carp	Fillet	8	43.0 - 50.0	3.5	0.92	26.3	UJ	0.74	21.1	UJ	0.73	20.9	UJ	0.66	18.9	UJ	0.69	19.7	UJ
Carp	WB-fillet	9	43.0 - 50.0	7.6	0 39	5.1	J	0.65	8.6	UJ	0.68	8.9	J	0.81	10.7	UJ	0.84	11.1	UJ
Carp	WB	14	56.5 - 71.9	6.1	0.18	3.0	J	0.57	9.3	J	0.70	11.5	J	0.078	1.3	UJ	0.22	3.6	J
Pikeminnow	Fillet	10	43.0 - 50.0	1.8	0.68	37.8	UJ	0.46	25.6	J	1.1	61.1	J	0.31	17.2	UJ	0.32	17.8	UJ
Pikeminnow	WB-fillet	11	43 0 - 50.0	8.1	0.30	3.7	U	0.78	9.6		0.42	5.2		0.049	0.6	U	0.078	1.0	U
Pikeminnow	WB	13	50 0 - 56.5	5.8	0.68	11.7	UJ	0.66	11.4	J	0.62	10.7	J	0.20	3.4	UJ	0.19	3.3	UJ
Pikeminnow	WB	15	56.5 - 71.9	3.6	0.14	3.9	J	0.28	7.8	J	0.16	4.4	J	0.03	0.8	UJ	0.031	0.9	UJ
Pikeminnow	WB	15	56.5 - 71.9	3.6	0.17	4.7	J	0.26	7.2	J	0.15	4.2	J	0.035	1.0	UJ	0.098	2.7	UJ
Sucker	Fillet	1	26.5 - 34 4	2.0	1.2	60.0	J	0.39	19.5		0.89	44.5		0.16	8.0	U	0.15	7.5	U
Sucker	Fillet	1	26.5 - 34 4	2.0	4.5	225.0	J	0.52	26.0	J	2.9	145.0		0.24	12.0	U	0.35	17.5	U
Sucker	WB-fillet	2	26.5 - 34 4	9.9	14	141.4	J	1.5	15.2		1.6	16.2	J	0.52	5.3	U	0.43	4.3	
Sucker	WB	12	50.0 - 56.5	7.9	0.52	6.6	J	0.8	10.1	J	0.44	5.6	J	0.14	1.8	J	0.22	2.8	J

Table B-3. PAH concentrations (ng/g) in composite fish samples collected from the Willamette River

				Chemical CAS#	Benz[b/j/k]fluoranthenes[c] 205-99-2/207-08-9			Benzo[e]pyrene 192-97-2			Benzo[a]pyrene 50-32-8			Perylene 198-55-0			Dibenz[ah]anthracene[d] 53-70-3		
					Concentration (ng/g)			Concentration (ng/g			Concentration (ng/g			Concentration (ng/g			Concentration (ng/g		
Species	Sample Type	Composite Sample	Collection Location	Percent Lipid	Wet Weight	Lipid Normalize	Qualifier	Wet Weight	Lipid Normalize	Qualifier	Wet Weight	Lipid Normalize	Qualifier	Wet Weight	Lipid Normalize	Qualifier	Wet Weight	Lipid Normalize	Qualifier
Bass	Fillet	6	34.4 - 43.0	1.4	1.1	78.6	U	1.1	78.6	U	1.4	100.0	U	1.1	78.6	U	0.28	20.0	U
Bass	Fillet	7	43.0 - 71.9	1.3	0.27	20.8	UJ	0.28	21.5	UJ	0.30	23.1	UJ	0.33	25.4	UJ	0.72	55.4	UJ
Carp	WB	3	43.0 - 71.9	7.2	6.0	83.3		3.4	47.2	J	4.3	59.7		1.9	26.4		0.97	13.5	U
Carp	WB	4	34.4 - 43.0	5.1	0.73	14.3	U	0.72	14.1	U	1.1	21.6	U	0.81	15.9	U	0.40	7.8	U
Carp	WB	5	34.4 - 43.0	8.5	0.56	6.6	UJ	0.58	6.8	UJ	0.61	7.2	UJ	0.69	8.1	UJ	0.75	8.8	UJ
Carp	Fillet	8	43.0 - 50.0	3.5	0.54	15.4	UJ	0.56	16.0	UJ	0.59	16.9	UJ	0.67	19.1	UJ	0.70	20.0	UJ
Carp	Fillet	8	43.0 - 50.0	3.5	0.78	22.3	UJ	0.82	23.4	UJ	0.85	24.3	UJ	0.92	26.3	UJ	1.1	31.4	UJ
Carp	WB-fillet	9	43.0 - 50.0	7.6	0.47	6.2	UJ	0.49	6.4	UJ	0.51	6.7	UJ	0.54	7.1	UJ	0.43	5.7	UJ
Carp	WB	14	56.5 - 71.9	6.1	0.063	1.0	UJ	0.18	3.0	UJ	0.17	2.8	UJ	0.22	3.6	UJ	0.091	1.5	UJ
Pikeminnow	Fillet	10	43.0 - 50.0	1.8	0.56	31.1	UJ	0.58	32.2	UJ	0.60	33.3	UJ	0.61	33.9	UJ	1.1	61.1	UJ
Pikeminnow	WB-fillet	11	43.0 - 50.0	8.1	1.3	16.0	U	1.3	16.0	U	1.4	17.3	U	2.0	24.7	U	0.80	9.9	
Pikeminnow	WB	13	50.0 - 56.5	5.8	0.89	15.3	UJ	3.6	62.1	UJ	0.88	15.2	UJ	0.76	13.1	UJ	0.064	1.1	UJ
Pikeminnow	WB	15	56.5 - 71.9	3.6	0.048	1.3	UJ	0.095	2.6	UJ	0.11	3.1	UJ	0.22	6.1	UJ	0.098	2.7	UJ
Pikeminnow	WB	15	56.5 - 71.9	3.6	0.15	4.2	UJ	0.11	3.1	UJ	0.13	3.6	UJ	0.17	4.7	UJ	0.15	4.2	UJ
Sucker	Fillet	1	26.5 - 34.4	2.0	0.38	19.0	U	0.32	16.0	U	0.47	23.5	U	0.75	37.5	U	0.50	25.0	U
Sucker	Fillet	1	26.5 - 34.4	2.0	0.50	25.0	U	0.48	24.0	U	0.70	35.0	U	0.98	49.0	U	1.2	60.0	U
Sucker	WB-fillet	2	26.5 - 34.4	9.9	0.85	8.6	U	0.81	8.2	U	1.2	12.1	U	1.3	13.1	J	0.47	4.7	U
Sucker	WB	12	50.0 - 56.5	7.9	0.078	1.0	J	0.099	1.3	J	0.14	1.8	J	0.48	6.1	J	0.089	1.1	UJ

				Chemical CAS#	Indeno[1,2,3-cd]pyrene 193-39-5			Benzo[ghi]perylene 191-24-2		
					Concentration (ng/g)			Concentration (ng/g		
Species	Sample Type	Composite Sample	Collection Location	Percent Lipid	Wet Weight	Lipid Normalize	Qualifier	Wet Weight	Lipid Normalize	Qualifier
Bass	Fillet	6	34.4 - 43.0	1.4	0.31	22.1	U	0.22	15.7	U
Bass	Fillet	7	43.0 - 71.9	1.3	0.63	48.5	UJ	0.56	43.1	UJ
Carp	WB	3	43.0 - 71.9	7.2	3.4	47.2		4.9	68.1	
Carp	WB	4	34.4 - 43.0	5.1	0.34	6.7	U	0.25	4.9	U
Carp	WB	5	34.4 - 43.0	8.5	0.48	5.6	UJ	0.42	4.9	UJ
Carp	Fillet	8	43.0 - 50.0	3.5	0.67	19.1	UJ	0.33	9.4	UJ
Carp	Fillet	8	43.0 - 50.0	3.5	0.93	26.6	UJ	0.82	23.4	UJ
Carp	WB-fillet	9	43.0 - 50.0	7.6	0.45	5.9	UJ	0.40	5.3	UJ
Carp	*WB*	*14*	*56.5 - 71.9*	*6.1*	*0.059*	*1.0*	J	*0.087*	*1.4*	J
Pikeminnow	Fillet	10	43.0 - 50.0	1.8	0.97	53.9	UJ	0.86	47.8	UJ
Pikeminnow	WB-fillet	11	43.0 - 50.0	8.1	0.55	6.8		0.68	8.4	
Pikeminnow	WB	13	50.0 - 56.5	5.8	0.043	0.7	UJ	0.052	0.9	J
Pikeminnow	WB	15	56.5 - 71.9	3.6	0.027	0.8	UJ	0.037	1.0	UJ
Pikeminnow	WB	15	56.5 - 71.9	3.6	0.09	2.5	UJ	0.073	2.0	UJ
Sucker	Fillet	1	26.5 - 34.4	2.0	0.28	14.0	U	0.30	15.0	U
Sucker	Fillet	1	26.5 - 34.4	2.0	0.54	27.0	U	0.63	31.5	U
Sucker	WB-fillet	2	26.5 - 34.4	9.9	0.46	4.6	J	1.1	11.1	
Sucker	WB	12	50.0 - 56.5	7.9	0.13	1.6	J	0.17	2.2	J

NOTE: CAS # - Chemical Abstracts Services
E - concentration is outside the linear calibration range
J - value should be considered an estimate
NQ - not quantifiable
U - not detected
WB - whole body

[a] Average of two percent lipid duplicates
[b] *May co-elute with triphenylene*
[c] May co-elute with benzo[j]fluoranthene
[d] May co-elute with dibenz[ac]anthracene

Table B-4. PCB Aroclor concentrations (ng/g) in composite fish samples collected from the Willamette River

					Chemical CAS#	Aroclor 1242 53469-21-9*			Aroclor 1254 11097-69-1*			Aroclor 1260 11096-82-5*		
						Concentration (ng/g)			Concentration (ng/g)			Concentration (ng/g)		
Species	Sample Type	te Sample	River Segment	Collection Location[a]	Percent Lipid	Wet Weight	Lipid Normalized	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier
Bass	Fillet	6	2	34.4 - 43.0	1.4	1.2	85.7		15	1071.4		11	785.7	
Bass	Fillet	7	3,4,5	43.0 - 71.9	1.3	1.3	100.0		13	1000.0		11	846.2	
Carp	WB	3	3,4,5	43.0 - 71.9	7.2	6.9	95.8		71	986.1		39	541.7	J
Carp	WB	3	3,4,5	43.0 - 71.9	7.2	7.7	106.9		87	1208.3		40	555.6	J
Carp	WB	4	2	34 4 - 43.0	5.1	3.9	76.5		60	1176.5		65	1274.5	J
Carp	WB	5	2	34.4 - 43 0	8.5	7.6	89.4		110	1294.1		120	1411.8	J
Carp	Fillet	8	3	43.0 - 50 0	3.5	3.0	85.7		36	1028.6		32	914.3	J
Carp	WB-fillet	9	3	43.0 - 50.0	7.6	6.6	86.8		82	1078.9		65	855.3	J
Carp	WB-fillet	9	3	43.0 - 50.0	7.6	6.5	85.5		91	1197.4		69	907.9	J
Carp	WB	14	5	56.5 - 71.9	6.1	4.1	67.2		59	967.2		49	803.3	J
Pikeminnow	Fillet	10	3	43.0 - 50.0	1.8	3.4	188.9	U	16	888.9		17	944.4	
Pikeminnow	WB-fillet	11	3	43.0 - 50.0	8.1	6.8	84.0		100	1234.6		92	1135.8	J
Pikeminnow	WB	13	4	50.0 - 56 5	5.8	3.7	63.8		58	1000.0		62	1069.0	J
Pikeminnow	WB	15	5	56.5 - 71.9	3.6	2.4	66.7		28	777.8		17	472.2	J
Sucker	Fillet	1	1	26.5 - 34.4	2.0	30	1500.0	U	63	3150.0	U	46	2300 0	U
Sucker	WB-fillet	2	1	26.5 - 34.4	9.9	9.6	97.0		88	888.9		58	585.9	J
Sucker	WB	12	4	50.0 - 56.5	7.9	6.7	84.8		53	670.9		36	455.7	J

NOTE: CAS # - Chemical Abstracts Services
DL - detection limit
nd - non-detects
U - undetected
WB - whole body

* - USEPA Environmental Monitoring Methods Index (EMMI) EPA#821-B-92-001

[a] Segment 4 terminated at mouth of Yamhill River prior to RM 50 due to dredging activities in main channel

Table B-5. PCB congener concentrations (ng/g) in composite fish samples collected from the Willamette River

			Composite 1				Composite 2				Composite 3				Composite 4			
			Species Sucker				Species Sucker				Species Carp				Species Carp			
			Sample Type Fillet				Sample Type WB-fillet				Sample Type WB				Sample Type WB			
				Concentration (pg/g)				Concentration (pg/g)				Concentration (pg/g)				Concentration (pg/g)		
Chemical	IUPAC NO.	CAS#	Percent Lipid	Wet Weight	Lipid Normalized	Data Qualifie	Percent Lipid	Wet Weight	Lipid Normalized	Data Qualifie	Percent Lipid	Wet Weight	Lipid Normalized	Data Qualifie	Percent Lipid	Wet Weight	Lipid Normalized	Data Qualifie
33'44'-TeCB	77	32598-13-3	2.0	12	600		9.9	82	828		7.2	84	1167		5.1	52	1020	
233'44'-PeCB	105	32598-14-4	2.0	360	18000		9.9	2500	25253		7.2	2100	29167		5.1	1800	35294	
2344'5-PeCB	114	74472-37-0	2.0	31	1550		9.9	190	1919		7.2	160	2222		5.1	160	3137	
23'44'5-PeCB	118	31508-00-6	2.0	1200	60000		9.9	7800	78788		7.2	7600	105556		5.1	6400	125490	
2'344'5-PeCB	123	65510-44-3	2.0	45	2250		9.9	280	2828		7.2	210	2917	J	5.1	220	4314	
33'44'5-PeCB	126	57465-28-8	2.0	2.9	145	U	9.9	16	162		7.2	17	236		5.1	14	275	
233'44'5-HxCB	156/157	1380-08-4 / 69782-90-7	2.0	170	8500		9.9	1100	11111		7.2	780	10833	C	5.1	1100	21569	
23'44'55'-HxCB	167	52663-72-6	2.0	74	3700		9.9	470	4747		7.2	370	5139		5.1	510	10000	
33'44'55'-HxCB	169	32774-16-6	2.0	3.2	160	J	9.9	18	182	J	7.2	19	264		5.1	20	392	J
22'33'44'5-HpCB	170	35065-30-6	2.0	320	16000		9.9	2000	20202		7.2	1400	19444		5.1	2400	47059	
22'344'55'-HpCB	180/193	a	2.0	850	42500		9.9	5900	59596		7.2	4500	62500	C	5.1	7200	141176	
233'44'55'-HpCB	189	39635-31-9	2.0	13	650		9.9	84	848		7.2	58	806		5.1	110	2157	

			Composite 5				Composite 6				Composite 7				Composite 8			
			Species Carp				Species Bass				Species Bass				Species Carp			
			Sample Type WB				Sample Type Fillet				Sample Type Fillet				Sample Type Fillet			
				Concentration (pg/g)				Concentration (pg/g)				Concentration (pg/g)				Concentration (pg/g)		
Chemical	IUPAC NO.	CAS#	Percent Lipid	Wet Weight	Lipid Normalized	Data Qualifie	Percent Lipid	Wet Weight	Lipid Normalized	Data Qualifie	Percent Lipid	Wet Weight	Lipid Normalized	Data Qualifie	Percent Lipid	Wet Weight	Lipid Normalized	Data Qualifie
33'44'-TeCB	77	32598-13-3	8.5	99	1165		1.4	12	857		1.3	14	1077		3.5	38	1086	
233'44'-PeCB	105	32598-14-4	8.5	2800	32941		1.4	420	30000		1.3	470	36154		3.5	1000	28571	
2344'5-PeCB	114	74472-37-0	8.5	280	3294		1.4	39	2786		1.3	42	3231		3.5	92	2629	
23'44'5-PeCB	118	31508-00-6	8.5	11000	129412		1.4	1300	92857		1.3	1600	123077		3.5	3800	108571	
2'344'5-PeCB	123	65510-44-3	8.5	270	3176		1.4	33	2357		1.3	33	2538		3.5	140	4000	J
33'44'5-PeCB	126	57465-28-8	8.5	24	282	U	1.4	3.7	264		1.3	4.7	362	U	3.5	8.9	254	
233'44'5-HxCB	156/157	1380-08-4 / 69782-90-7	8.5	1800	21176		1.4	210	15000	C	1.3	250	19231		3.5	600	17143	
23'44'55'-HxCB	167	52663-72-6	8.5	870	10235		1.4	80	5714		1.3	87	6692		3.5	280	8000	
33'44'55'-HxCB	169	32774-16-6	8.5	36	424	J	1.4	2.9	207		1.3	4.7	362	J	3.5	11	314	J
22'33'44'5-HpCB	170	35065-30-6	8.5	4000	47059		1.4	340	24286		1.3	370	28462		3.5	1100	31429	
22'344'55'-HpCB	180/193	a	8.5	13000	152941		1.4	950	67857	C	1.3	980	75385		3.5	3000	85714	
233'44'55'-HpCB	189	39635-31-9	8.5	180	2118		1.4	12	857		1.3	17	1308		3.5	50	1429	

Table B-5. PCB congener concentrations (ng/g) in composite fish samples collected from the Willamette River

			Composite 9				Composite 10				Composite 11				Composite 12			
			Species	Carp			Species	Pikeminnow			Species	Pikeminnow			Species	Sucker		
			Sample Type	WB-fillet			Sample Type	Fillet			Sample Type	WB-fillet			Sample Type	WB		
				Concentration (pg/g)				Concentration (pg/g)				Concentration (pg/g)			Concentration (pg/g)			
Chemical	IUPAC NO.	CAS#	Percent Lipid	Wet Weight	Lipid Normalized	Data Qualifie	Percent Lipid	Wet Weight	Lipid Normalized	Data Qualifie	Percent Lipid	Wet Weight	Lipid Normalized	Data Qualifie	Percent Lipid	Wet Weigh	Lipid Normaliz	Data Qualifie
33'44'-TeCB	77	32598-13-3	7.6	84	1105		1.8	35	1944		8.1	190	2346		7.9	68	861	
233'44'-PeCB	105	32598-14-4	7.6	2300	30263		1.8	750	41667		8.1	3800	46914		7.9	1700	21519	
2344'5-PeCB	114	74472-37-0	7.6	220	2895		1.8	71	3944		8.1	370	4568		7.9	120	1519	
23'44'5-PeCB	118	31508-00-6	7.6	9200	121053		1.8	2500	138889		8.1	13000	160494		7.9	5100	64557	
2'344'5-PeCB	123	65510-44-3	7.6	270	3553		1.8	61	3389		8.1	320	3951		7.9	200	2532	J
33'44'5-PeCB	126	57465-28-8	7.6	21	276		1.8	6.7	372		8.1	38	469		7.9	16	203	
233'44'5-HxCB	156/157	1380-08-4 / 69782-90-7	7.6	1400	18421		1.8	400	22222		8.1	2000	24691		7.9	790	10000	C
23'44'55'-HxCB	167	52663-72-6	7.6	680	8947		1.8	170	9444		8.1	820	10123		7.9	330	4177	
33'44'55'-HxCB	169	32774-16-6	7.6	20	263	J	1.8	6.1	339	J	8.1	35	432		7.9	20	253	
22'33'44'5-HpCB	170	35065-30-6	7 6	2500	32895		1.8	610	33889		8.1	2900	35802		7.9	1400	17722	
22'344'55'-HpCB	180/193	8	7.6	8600	113158		1.8	1800	100000		8.1	9900	122222		7.9	3600	45570	C
233'44'55'-HpCB	189	39635-31-9	7.6	120	1579		1.8	30	1667		8.1	160	1975		7.9	59	747	

			Composite 13				Composite 14				Composite 15			
			Species	Pikeminnow			Species	Carp			Species	Pikeminnow		
			Sample Type	WB			Sample Type	WB			Sample Type	WB		
			Concentration (pg/g)				Concentration (pg/g)				Concentration (pg/g)			
Chemical	IUPAC NO.	CAS#	Percent Lipid	Wet Weigh	Lipid Normalized	Data Qualifie	Percent Lipid	Wet Weigh	Lipid Normalized	Data Qualifie	Percent Lipid	Wet Weight	Lipid Normalized	Data Qualifie
33'44'-TeCB	77	32598-13-3	5.8	100	1724		6.1	70	1148		3.6	62	1722	
233'44'-PeCB	105	32598-14-4	5.8	2400	41379		6.1	1600	26230		3.6	1200	33333	
2344'5-PeCB	114	74472-37-0	5.8	220	3793		6.1	130	2131		3.6	74	2056	
23'44'5-PeCB	118	31508-00-6	5.8	9700	167241		6.1	6800	111475		3.6	4100	113889	
2'344'5-PeCB	123	65510-44-3	5.8	210	3621	J	6.1	200	3279		3.6	86	2389	
33'44'5-PeCB	126	57465-28-8	5.8	21	362		6.1	15	246		3.6	9.0	250	
233'44'5-HxCB	156/157	1380-08-4 / 69782-90-7	5.8	1600	27586	C	6.1	930	15246		3.6	470	13056	
23'44'55'-HxCB	167	52663-72-6	5.8	770	13276		6.1	440	7213		3.6	180	5000	
33'44'55'-HxCB	169	32774-16-6	5.8	27	466		6.1	22	361		3.6	9.0	250	
22'33'44'5-HpCB	170	35065-30-6	5.8	1800	31034		6.1	1900	31148		3.6	650	18056	
22'344'55'-HpCB	180/193	8	5.8	7400	127586	C	6.1	6700	109836		3.6	2100	58333	
233'44'55'-HpCB	189	39635-31-9	5.8	100	1724		6.1	90	1475		3.6	32	889	

Table B-6. Dioxin and furan concentrations (ng/kg) in composite fish samples collected from the Willamette River

				Chemical CAS#	2,3,7,8-TCDD 1746-01-6 Concentration (ng/kg			1,2,3,7,8-PeCDD 40321-76-4 Concentration (ng/kg			1,2,3,4,7,8-HxCDD 39227-28-6 Concentration (ng/kg			1,2,3,6,7,8-HxCDD 57653-85-7 Concentration (ng/kg			1,2,3,7,8,9-HxCDD 19408-74-3 Concentration (ng/kg		
Species	Sample Type	Composite Sample	Collection Location[a] (RM)	Percent Lipid	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier
Bass	Fillet	6	34.4 - 43.0	1.4	0.14	10		0.11	7.9		0.10	7.1	U	0.10	7.1	U	0.10	7.1	U
Bass	Fillet	7	43 0 - 71.9	1.3	0.10	7.7		0.10	7.7		0.10	7.7	U	0.10	7.7	U	0.10	7.7	U
Carp	WB	3	43.0 - 71.9	7.2	0.82	11		1.1	15		0.75	10		3.3	45		0.32	4.4	
Carp	WB	4	34.4 - 43 0	5.1	0.64	13		0.89	17		0.57	11		2.5	49		0.24	4.7	
Carp	WB	5	34.4 - 43 0	8.5	1.3	15		1.6	19		1.3	15		5.1	60		0.59	6.9	
Carp	Fillet	8	43.0 - 50.0	3.5	0.38	11		0.42	12		0.31	8.9		1.2	34		0.10	2.9	
Carp	WB-fillet	9	43.0 - 50.0	7.6	0.86	11		1.1	15		0.80	11		2.9	38		0.38	5.0	
Carp	WB	14	56.5 - 71.9	6.1	0.63	10		0.80	13		0.45	7.4		1.8	29		0.29	4.8	
Pikeminnow	Fillet	10	43.0 - 50.0	1.8	0.13	7.2		0.18	10		0.10	5.6	U	0.10	5.6	U	0.10	5.6	U
Pikeminnow	WB-fillet	11	43.0 - 50.0	8.1	0.70	8.6		1.1	14		0.50	6.2		2.1	26		0.10	1.2	U
Pikeminnow	WB	13	50.0 - 56.5	5.8	0.46	7.9		0.69	12		0.37	6.4		1.2	21		0.23	4.0	
Pikeminnow	WB	15	56.5 - 71.9	3.6	0.19	5.3		0.25	6.9		0.12	3.3		0.46	13		0.08	2.2	
Sucker	Fillet	1	26.5 - 34.4	2.0	0.08	4.0		0.06	3.0		0.10	5.0	U	0.10	5.0	U	0.10	5.0	U
Sucker	WB-fillet	2	26.5 - 34.4	9.9	0.47	4.7		0.43	4.3		0.15	1.5		0.55	5.6		0.10	1.0	U
Sucker	WB	12	50 0 - 56.5	7 9	0.39	4.9		0.58	7.3		0.33	4.2		0.77	9.7		0.22	2.8	

				Chemical CAS#	1,2,3,4,6,7,8-HpCDD 35822-46-9 Concentration (ng/kg			OCDD 3268-87-9 Concentration (ng/kg			2,3,7,8-TCDF 51207-31-9 Concentration (ng/kg			1,2,3,7,8-PeCDF 57177-41-6 Concentration (ng/kg			2,3,4,7,8-PeCDF 57117-31-4 Concentration (ng/kg		
Species	Sample Type	Composite Sample	Collection Location[a] (RM)	Percent Lipid	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier
Bass	Fillet	6	34.4 - 43.0	1.4	0.15	10.7	U	0.30	21.4	U	0.17 [b]	12		0.07	5.0	U	0.07	5.0	U
Bass	Fillet	7	43.0 - 71.9	1.3	0.15	12	U	0.30	23	U	0.14	11		0.05	3.8	U	0.08	6.2	
Carp	WB	3	43 0 - 71.9	7.2	6.0	83		7.4	103		1.1	15		0.28	3.9		0.69	9.6	
Carp	WB	4	34.4 - 43.0	5.1	4.6	91		6.4	126		0.69	14		0.11	2.2	U	0.47	9.2	
Carp	WB	5	34 4 - 43.0	8.5	9.6	113		11	129		1.3	15		0.38	4.5		1.1	12	
Carp	Fillet	8	43.0 - 50.0	3.5	2.1	59		1.9	54		0.40	11		0.10	2.9		0.29	8.3	
Carp	WB-fillet	9	43.0 - 50 0	7.6	5.2	69		5.5	72		0.95	13		0.28	3.7		0.70	9.2	
Carp	WB	14	56.5 - 71 9	6.1	3.7	61		5.1	83		0.95	16		0.21	3.4		0.49	8.0	
Pikeminnow	Fillet	10	43 0 - 50.0	1.8	0.51	28		0.89	49		0.44	24		0.08	4.4	U	0.13	7.2	
Pikeminnow	WB-fillet	11	43.0 - 50.0	8.1	3.3	41		3.7	46		2.8	35		0.29	3.6		0.78	9.6	
Pikeminnow	WB	13	50.0 - 56.5	5.8	2.0	34		2.9	49		1.5	26		0.09	1.6	U	0.53	9.1	
Pikeminnow	WB	15	56.5 - 71.9	3.6	0.91	25		1.6	44		0.68	19		0.09	2.5	U	0.17	4.7	
Sucker	Fillet	1	26.5 - 34.4	2.0	0.14	7.0		0.45	23		0.14	7.0		0.05	2.5	U	0.05	2.5	U
Sucker	WB-fillet	2	26.5 - 34.4	9.9	2.0	21		11	115		0.85	8.6		0.10	1.0		0.22	2.2	
Sucker	WB	12	50.0 - 56.5	7.9	1.3	16		2.7	34		0.97	12		0.18	2.3		0.48	6.1	

Table B-6. Dioxin and furan concentrations (ng/kg) in composite fish samples collected from the Willamette River

				Chemical CAS#	1,2,3,4,7,8-HxCDF 70648-26-9 Concentration (ng/kg			1,2,3,6,7,8-HxCDF 57117-44-9 Concentration (ng/kg			1,2,3,7,8,9-HxCDF 72918-21-9 Concentration (ng/kg			2,3,4,6,7,8-HxCDF 60851-34-5 Concentration (ng/kg			1,2,3,4,6,7,8-HpCDF 67562-39-4 Concentration (ng/kg		
Species	Sample Type	Composite Sample	Collection Location[a] (RM)	Percent Lipid	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier
Bass	Fillet	6	34.4 - 43.0	1.4	0.10	7.1	U	0.10	7.1	U	0.10	7.1	U	0.10	7.1	U	0.15	10.7	U
Bass	Fillet	7	43.0 - 71.9	1 3	0.10	7.7	U	0.10	7.7	U	0.10	7.7	U	0.10	7.7	U	0.15	12	U
Carp	WB	3	43 0 - 71.9	7.2	0.39	5.4		0.28	3.9		0.10	1.4	U	0.15	2.1		0.17	2.4	U
Carp	WB	4	34.4 - 43 0	5.1	0.26	5.1		0.17	3.3		0.10	2.0	U	0.14	2.7		0.15	2.9	U
Carp	WB	5	34.4 - 43 0	8 5	0.65	7 6		0.40	4.7		0.10	1.2	U	0.26	3.1		1.1	13	
Carp	Fillet	8	43.0 - 50 0	3.5	0.15	4.3		0.10	2.9	U	0.10	2.9	U	0.10	2.9	U	0.15	4.3	U
Carp	WB-fillet	9	43.0 - 50 0	7.6	0.42	5.5		0.30	3.9		0.10	1.3	U	0.26	3.4		0.65	8.6	
Carp	WB	14	56.5 - 71 9	6.1	0.25	4.1		0.22	3.6		0.10	1.6	U	0.21	3.4		0.48	7.9	
Pikeminnow	Fillet	10	43.0 - 50 0	1.8	0.10	5.6	U	0.10	5.6	U	0.10	5.6	U	0.10	5.6	U	0.15	8.3	U
Pikeminnow	WB-fillet	11	43.0 - 50.0	8.1	0.30	3.7		0.20	2 5		0.10	1.2	U	0.18	2.2		0.15	1.9	U
Pikeminnow	WB	13	50.0 - 56.5	5 8	0.10	1.7	U	0.16	2.8		0.10	1.7	U	0.19	3.3		0.28	4.8	
Pikeminnow	WB	15	56.5 - 71.9	3.6	0.10	2.8	U	0.10	2.8	U	0.10	2.8	U	0.10	2.8	U	0.15	4.2	U
Sucker	Fillet	1	26 5 - 34.4	2 0	0.10	5.0	U	0.10	5.0	U	0.10	5.0	U	0.10	5.0	U	0.15	7.5	U
Sucker	WB-fillet	2	26.5 - 34.4	9 9	0.10	1 0	U	0.10	1.0	U	0.10	1.0	U	0.10	1.0	U	0.15	1.5.	U
Sucker	WB	12	50.0 - 56 5	7 9	0.22	2.8		0.18	2.3		0.20	2.5		0.26	3.3		0.27	3.4	

				Chemical CAS#	1,2,3,4,7,8,9-HpCDF 55673-89-7 Concentration (ng/kg			OCDF 39001-02-0 Concentration (ng/kg			TEC (nd = DL) Concentration (ng/kg			TEC (nd = 1/2 DL) Concentration (ng/kg			TEC (nd= 0) Concentration (ng/kg		
Species	Sample Type	Composite Sample	Collection Location[a] (RM)	Percent Lipid	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier	Wet Weight	Lipid Normalize	Data Qualifier
Bass	Fillet	6	34 4 - 43.0	1.4	0.15	10.7	U	0.30	21.4	U	0.38	27		0.32	23		0.27	19	
Bass	Fillet	7	43 0 - 71.9	1.3	0.15	12	U	0.30	23	U	0.33	25		0.29	23		0.25	20	
Carp	WB	3	43 0 - 71.9	7.2	0.17	2.4	U	0.30	4.2		3.0	41		3.0	41		3.0	41	
Carp	WB	4	34.4 - 43 0	5.1	0.15	2.9	U	0.30	5.9	U	2.3	45		2.3	45		2.3	45	
Carp	WB	5	34.4 - 43 0	8.5	0.15	1.8	U	0.30	3.5	U	4.6	54		4.6	54		4.6	54	
Carp	Fillet	8	43.0 - 50 0	3 5	0.15	4.3	U	0.30	8 6	U	1.2	35		1.2	34		1.2	34	
Carp	WB-fillet	9	43 0 - 50.0	7.6	0 15	2.0	U	0.30	3.9	U	3.0	40		3.0	39		3.0	39	
Carp	WB	14	56.5 - 71.9	6.1	0.15	2.5	U	0.30	4.9	U	2.2	35		2.1	35		2.1	35	
Pikeminnow	Fillet	10	43 0 - 50.0	1.8	0.15	8.3	U	0.30	17	U	0.50	28		0.46	26		0.42	24	
Pikeminnow	WB-fillet	11	43.0 - 50.0	8.1	0.15	1.9	U	0.30	3.7	U	2.9	36		2.9	36		2.9	36	
Pikeminnow	WB	13	50 0 - 56.5	5.8	0.15	2.6	U	0.30	5.2	U	1.8	32		1.8	31		1.8	31	
Pikeminnow	WB	15	56 5 - 71.9	3.6	0.15	4.2	U	0.30	8.3	U	0.72	20		0.69	19		0.67	19	
Sucker	Fillet	1	26.5 - 34.4	2.0	0.15	7.5	U	0.30	15	U	0.26	13		0.21	10		0.16	7.8	
Sucker	WB-fillet	2	26.5 - 34.4	9.9	0.15	1.5	U	0.55	5.6		1.2	13		1.2	12		1.2	12	
Sucker	WB	12	50.0 - 56 5	7.9	0.20	2.5		0.47	5.9		1.6	20		1.6	20		1.6	20	

NOTE: CAS # - Chemical Abstracts Services
DL - detection limit
nd - non-detects
TEC - toxicity equivalent concentration
U - undetected
WB - whole body
WB-fillet - whole body minus the fillet portions
[a] Segment 4 terminated at mouth of Yamhill River prior to RM 50 due to dredging activities in main channel
[b] Average of 2 duplicates (0 15 and 0.19 ng/kg)

APPENDIX C

Data Quality Assurance Review

DATA QUALITY ASSURANCE REVIEW

Project data quality objectives were established in the Quality Assurance Project Plan (QAPP) (EVS 1999). The overall quality assurance objective for this project was to collect analytical data of known and acceptable quality so that potential health risk to fish consumers could be estimated. Data quality objectives (DQOs) were established for holding times, accuracy, precision, detection limits, and completeness to ensure that the data of acceptable quality were obtained in this project (Table C-1). The DQOs established for each chemical method are discussed below along with an assessment of data collected during this project.

METALS

Fifteen composite fish samples were analyzed for silver, arsenic, beryllium, cadmium, chromium, copper, nickel, lead, antimony, thallium, and zinc via inductively coupled plasma-mass spectrometry using USEPA Method 1638/ 200.8 modified (EVS 1999). Mercury was analyzed via cold vapor atomic fluorescence using USEPA Method 1631modified. Total inorganic arsenic was analyzed by atomic absorption spectrometry using USEPA Method 1632 modified. Frontier Geosciences, Inc. in Seattle, Washington performed all metal analyses.

Holding Times

Axys Analytical Services, Ltd. prepared the composite samples and shipped tissue homogenate samples to Frontier Geosciences. All homogenate samples arrived at Frontier Geosciences on September 21, 1999. A holding time of two years was established as the DQO for all metals except mercury; the holding time for mercury was 86 days (EVS 1999). The 86-day mercury holding time determined from the earliest collection date for individual fish used to form a composite sample expired on November 5-13, 1999. All analyses for total mercury occurred prior to these dates from October 8 to October 10, 1999. All other metal analyses were conducted between October 8, 1999 and November16, 1999, well within the two year holding time for this study.

Accuracy

Three standard reference materials (SRMs) were analyzed along with the samples to assess accuracy. DORM-2 is a dogfish muscle standard; DOLT-2 is a dogfish liver standard, and NIST 1643d is a freshwater standard. The percent recoveries determined from analyses of these SRMs were within the range of 60 to 140 percent established as a data quality objective for this study for all metals except chromium and nickel (Table C-2). The percent recovery for chromium in dogfish muscle (47.6 percent) was

Table C-1. Summary of data quality objectives for analyses

Parameter	Units	Method Detection Limit	Sample Size	Precision (RPD)	Accuracy	Completeness	Method	Reference	Container (Field/ Laboratory)	Sample Holding Time	Preservative
Metals											
11 metals[a]	mg/kg	0.005–0.1	5 g	30%	60–140%	90%	ICP-MS	USEPA Method 1638/ 200.8 mod.	Aluminum foil/glass	2 years	Freeze
Arsenic (inorganic)	mg/kg	0.05	from 5g for metals	30%	60–140%	90%	HG-CT-AAS	USEPA Method 1632 mod.	Collected with metals	2 years	Freeze
Mercury	mg/kg	0.0005	from 5g for metals	30%	60–140%	90%	CV-AFS	USEPA Method 1631 mod.	Collected with metals	86 days	Freeze
Pesticides	µg/kg	0.1–2	from 10g for PCB Aroclors	50%	30–150%	90%	HRGC-LRMS	Axys Method CL-T-03, Version 2 1997	Collected with PCBs	1 year (sample) 40 days (extract)	Freeze
PAHs	µg/kg	0.1–0.3[b]	10 g	50%	30–140%	90%	HRGC-LRMS	Axys Method PH-01, Version 2 1997	Aluminum foil/glass	1 year (sample) 40 days (extract)	Freeze
PCB Aroclors	µg/kg	1–2	10 g	50%	30–150%	90%	HRGC-LRMS	Axys Method CL-T-03, Version 2 1997	Aluminum foil/glass	1 year (sample) 40 days (extract)	Freeze
PCB congeners	ng/kg	5.0	10 g	40%	70–140%	90%	HRGC-HRMS	USEPA Method 1668	Aluminum foil/glass	1 year (sample) 1 year (extract)	Freeze
Dioxins/ furans	ng/kg	0.05–0.3	10 g	40%	70–140%	90%	HRGC-HRMS	USEPA Method 1613B	Aluminum foil/glass	1 year (sample) 1 year (extract)	Freeze
Moisture content	%	0.1	10 g	10%	±20%	90%	Gravimetric	Axys SOP Lab-15 Revision 1	Collected with PCBs	6 months	Freeze
Percent lipids	%	0.1	5 g	30%	na	90%	Gravimetric	Bligh and Dyer 1959	Collected with PCBs	1 year	Freeze

NOTE: PAH - polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
ICP-MS – inductively coupled plasma-atomic emission spectrometry/mass spectrometry
HRGC - high resolution gas chromatography
LRMS - low resolution mass spectrometry
HRMS - high resolution mass spectrometry

[a] Antimony, arsenic, beryllium, cadmium, chromium, copper, lead, nickel, silver, thallium, and zinc

[b] Parent PAH

Table C-2. Standard reference material (SRM) analyses for metals

Analyte	SRM	Certified Conc. (mg/kg)	Measured Conc. (mg/kg)	Percent Recovery (%)
Silver	DORM-2	0.041	0.05	122.0
Arsenic	DORM-2	18.00	17.08	94.9
Beryllium	DORM-2	na	na	na
Cadmium	DORM-2	0.043	0.04	93.0
Chromium	DORM-2	34.70	16.50	47.6
Copper	DORM-2	2.34	2.01	85.9
Mercury	DORM-2	4.640	4.341	93.6
Nickel	DORM-2	19.40	9.69	49.9
Lead	DORM-2	0.065	0.049	75.4
Antimony	DORM-2	na	na	na
Thallium	DORM-2	na	na	na
Zinc	DORM-2	25.60	21.42	83.7
Silver	DOLT-2	0.608	0.61	100.3
Arsenic	DOLT-2	56.02	54.13	96.6
Beryllium	DOLT-2	na	na	na
Cadmium	DOLT-2	20.80	19.01	91.4
Chromium	DOLT-2	0.37	0.83	224.3
Copper	DOLT-2	25.80	27.87	108.0
Mercury	DOLT-2	2.140	1.980	92.5
Nickel	DOLT-2	0.20	0.23	115.0
Lead	DOLT-2	0.220	0.196	89.1
Antimony	DOLT-2	na	na	na
Thallium	DOLT-2	na	na	na
Zinc	DOLT-2	85.80	81.54	95.0
Silver	NIST 1643d	1.270	1.15	90.6
Arsenic	NIST 1643d	16.60	14.20	85.5
Beryllium	NIST 1643d	12.53	12.3	98.2
Cadmium	NIST 1643d	6.47	6.32	97.7
Chromium	NIST 1643d	18.53	18.77	101.3
Copper	NIST 1643d	20.50	22.15	108.0
Mercury	NIST 1643d	1.400	1.376	98.3
Nickel	NIST 1643d	58.10	58.80	101.2
Lead	NIST 1643d	18.18	18.49	101.7
Antimony	NIST 1643d	54.10	53.62	99.1
Thallium	NIST 1643d	7.28	7.65	105.1
Zinc	NIST 1643d	85.80	81.54	95.0

NOTE: na - not available

below the DQO of 60 percent, while the percent recovery in dogfish liver (224.3 percent) was well above the upper DQO of 140 percent. The percent recovery of chromium in the freshwater sample (101.3 percent) was within acceptable DQO limits. The percent recovery of nickel in dogfish muscle (49.9 percent) was below the DQO of 60 percent. Nickel analyses for the other two SRMs were within acceptable percent recovery limits. The average percent recovery for all metals except chromium and nickel was 95.9 percent.

Precision

The precision of metal analyses was assessed by performing a duplicate analysis of Composite 2 (largescale sucker: whole body minus fillets) for all metals except inorganic arsenic. The precision of inorganic arsenic was assessed by performing a duplicate analysis of Composite 1 (largescale sucker: whole body). Table C-3 shows the results of these analyses along with the measure of precision expressed as a relative percent difference (RPD). The RPDs for silver (85.7 percent) and antimony (66.7 percent) exceeded the DQO for precision of 30 percent for metals (EVS 1999). The concentration of silver and antimony in the duplicate samples were near their respective detection limits of 0.01 and 0.001 mg/kg, which may account for the higher variability of the analyses. The average RPD of all metals except silver and antimony was 4.4 percent.

Table C-3. Laboratory duplicate analyses for metals

Analyte	Sample ID	Replicate 1 Conc. (mg/kg)	Replicate 2 Conc. (mg/kg)	RPD (%)
Silver	Composite #2	0.05	0.02	85.7
Arsenic	Composite #2	0.17	0.15	12.5
Inorganic Arsenic	Composite #1	0.004	0.004	0.0
Beryllium	Composite #2	0.006	0.007	15.4
Cadmium	Composite #2	0.01	0.01	0.0
Chromium	Composite #2	0.62	0.61	1.6
Copper	Composite #2	2.86	2.78	2.8
Mercury	Composite #2	0.096	0.100	4.1
Nickel	Composite #2	0.51	0.50	2.0
Lead	Composite #2	0.141	0.135	4.3
Antimony	Composite #2	0.001	0.002	66.7
Thallium	Composite #2	ND	ND	na
Zinc	Composite #2	17.52	17.28	1.4

NOTE: RPD - relative percent difference
ND - not detected
na - not applicable

Detection Limits

Table C-4 shows the method detection limits achieved for the analysis of metals in this study. The detection limits for all metals except mercury were within the range of detection limits of 0.005–0.1 mg/kg established as a DQO for this study. The detection limit achieved for mercury, 0.003 mg/kg, was higher than the DQO of 0.0005 mg/kg. However, all sample results for mercury had detected concentrations that were a minimum of 10 times the detection limit, so the detection limit achieved has no affect on the data quality.

Table C-4. Method detection limits for metal analyses

ANALYTE	METHOD DETECTION LIMIT (mg/kg)
Silver	0.01
Arsenic	0.05
Inorganic Arsenic	0.003
Beryllium	0.001
Cadmium	0.01
Chromium	0.02
Copper	0.01
Mercury	0.003
Nickel	0.01
Lead	0.005
Antimony	0.001
Thallium	0.002
Zinc	0.06

Completeness

Completeness is the percentage of valid results obtained as compared to the total number of samples taken for a parameter. A completeness of 90 percent was established as a DQO for this study. All analyses of metals were considered to be valid and of acceptable quality for this risk assessment.

PAHs

Fifteen composite fish samples were analyzed for polycyclic aromatic hydrocarbons using Axys Method PH-01, Version 2. Tissue samples were spiked with 12 PAH surrogate samples and solvent extracted. The raw extract was fractionated on silca gel into polar and non-polar fractions. The polar fraction was analyzed for PAHs by high resolution gas chromatography (HRGC) / low resolution mass spectrometry (LRMS). HRGC/LRMS analysis was conducted using a Finnigan Incos 50 mass spectrometer equipped with a Varian 3400 gas chromatograph. The final volume of sample extracts was 20 µl; 1 µl was injected onto a Restek Rt_x-5 gas chromatography column.

Holding Times

A holding time of 40 days for sample extraction and 1 year for PAH analysis was established as a DQO for this study (EVS 1999). These holding times were met for 6 of the 15 tissue samples analyzed (Table C-5). The extraction holding times were exceeded by 14 to 73 days for the remaining 9 samples. The PAH data for all samples for which extraction holding times were exceeded have been qualified as estimates using a J data qualifier. All samples were analyzed prior to the 1-year holding time DQO (Table C-5).

Table C-5. Extraction and analysis holding times for PAH analyses

Composite No.	Species	Sample Type	Collection Date[a]	Extraction Date	Analysis Date	Extraction Holding Time (days)	Analysis Holding Time (days)
1	Sucker	F	8/11/1999	9/14/1999	10/29/1999	34	79
2	Sucker	WB-F	8/11/1999	9/14/1999	10/30/1999	34	80
3	Carp	WB	8/12/1999	9/14/1999	10/30/1999	33	79
4	Carp	WB	8/12/1999	9/14/1999	10/30/1999	33	79
5	Carp	WB	8/18/1999	12/2/1999	12/8/1999	106	112
6	Bass	F	8/12/1999	9/14/1999	10/30/1999	33	79
7	Bass	F	8/11/1999	12/2/1999	12/8/1999	113	119
8	Carp	F	8/14/1999	12/2/1999	12/8/1999	110	116
9	Carp	WB-F	8/14/1999	12/2/1999	12/8/1999	110	116
10	Pikeminnow	F	8/13/1999	12/2/1999	12/8/1999	111	117
11	Pikeminnow	WB-F	8/13/1999	9/20/1999	11/2/1999	38	81
12	Sucker	WB	8/15/1999	10/9/1999	11/2/1999	55	79
13	Pikeminnnow	WB	8/15/1999	10/9/1999	11/2/1999	55	79
14	Carp	WB	8/16/1999	10/9/1999	11/2/1999	54	78
15	Pikeminnnow	WB	8/16/1999	10/9/1999	11/2/1999	54	78

NOTE: F - fillet with skin
WB - whole body
WB-F - whole body minus the fillets

[a] First date of collection for the individual fish comprising the composite sample.

Accuracy

Accuracy was assessed by calculating the percent recovery of nine isotope-labeled surrogate PAH standards in accordance with Axys Method PH-01, Version 2. Low percent recoveries outside the method acceptance limits were obtained for the analysis of naphthalene in five samples and for acenaphthene in one laboratory duplicate sample (Table C-6). The percent recoveries for all other samples were within the method acceptance limits. Chemical results associated with percent recoveries that fell outside the method acceptance limits have been qualified as estimates using a J data qualifier.

Table C-6. Matrix spike percent recovery results for deuterium-labeled PAH surrogate standards

	Composite No.																	
Labeled Compounds	1	1-D	2	3	4	5	6	7	8	8-D	9	10	11	12	13	14	15	15-D
Naphthalene d-8	30	NQ	16	16	12[a]	20	NQ	14[a]	12[a]	6.6	22	16	12[a]	14[a]	24	23	25	18
Acenaphthene d-10	45	26	35	37	32	41	34	22	20	18[b]	36	26	34	34	45	46	51	38
Phenanthrene d-10	75	60	66	70	52	65	59	42	42	34	57	43	56	51	61	57	77	63
Pyrene d-10	97	78	83	87	88	77	94	61	65	46	79	59	74	68	77	76	87	80
Chrysene d-12	100	78	78	79	74	77	100	73	64	49	80	58	87	77	87	86	94	83
Benzo[a]pyrene d-12	120	120	110	86	69	79	55	68	66	47	86	48	31	78	57	84	100	90
Perylene d-12	130	110	110	100	83	71	90	62	64	44	83	49	23	72	63	78	94	86
Dibenzo[ah]anthracene d-14	81	67	76	74	75	67	89	66	58	38	80	37	72	56	72	62	78	58
Benzo[ghi]perylene d-12	110	91	100	92	88	65	110	73	62	44	81	41	74	60	78	67	89	70

NOTE: NQ = not quantifiable
D - duplicate

[a] Surrogate recovery is outside the acceptance limits of 15–120 percent for naphthalene.
[b] Surrogate recovery is outside the acceptance limits of 20–120 percent for acenaphthene.

Precision

Precision was assessed by analyzing laboratory duplicates for three tissue samples (Table C-7). Nine PAHs were not detected in any of the three sample-duplicate pairs. The relative percent difference (RPD) of the duplicate analyses fell outside the 50 percent DQO established for this study for acenaphthene, anthracene, and pyrene in Composite 1, a composite sample of largescale sucker fillets. All other detected PAHs in these samples had RPD values ranging from 6 to 19 percent.

Detection Limits

Detection limits achieved for the analysis of PAH compounds are shown in Table C-8. With the exception of Composite 12 (whole body largescale sucker), Composite 14 (whole body carp), and Composite 15 (whole body northern pikeminnow) and, all

Table C-7. Laboratory duplicate analyses for PAHs

	Composite 1		Composite 1-dup			Composite 8		Composite 8-dup			Composite 15		Composite 15-dup		
Chemical	Conc. (µg/kg)	Qual.	Conc (µg/kg)	Qual	RPD (%)	Conc. (µg/kg)	Qual.	Conc (µg/kg)	Qual	RPD (%)	Conc. (µg/kg)	Qual.	Conc (µg/kg)	Qual	RPD (%)
Naphthalene	5.2		NQ	NQ	na	13	J	12	J	8	4.1	J	4	J	2
Acenaphthylene	0.64		0.53		19	1.8	UJ	1.4	UJ	na	0.52	J	0.56	J	7
Acenaphthene	0.21		0.67	U	105	1.9	UJ	1.5	UJ	na	2.2	J	2.4	J	9
Fluorene	0.51		0.62		19	1.9	UJ	1.5	UJ	na	1.2	J	1.3	J	8
Phenanthrene	0.33	J	0.38	J	14	1.9	J	1.7	J	11	1.2	J	1.4	J	15
Anthracene	1.2	J	4.5	J	116	0.86	UJ	0.92	UJ	na	0.14	J	0.17	J	19
Fluoranthene	0.39		0.52	J	29	0.56	UJ	0.74	UJ	na	0.28	J	0.26	J	7
Pyrene	0.89		2.9		106	0.62	J	0.73	UJ	16	0.16	J	0.15	J	6
Benz[a]anthracene	0.16	U	0.24	U	na	0.57	UJ	0.66	UJ	na	0.03	UJ	0.035	UJ	na
Chrysene	0.15	U	0.35	U	na	0.59	UJ	0.69	UJ	na	0.031	UJ	0.098	UJ	na
Benzo[b,j,k]fluoranthenes	0.38	U	0.5	U	na	0.54	UJ	0.78	UJ	na	0.048	UJ	0.15	UJ	na
Benzo[e]pyrene	0.32	U	0.48	U	na	0.56	UJ	0.82	UJ	na	0.095	UJ	0.11	UJ	na
Benzo[a]pyrene	0.47	U	0.7	U	na	0.59	UJ	0.85	UJ	na	0.11	UJ	0.16	UJ	na
Perylene	0.75	U	0.98	U	na	0.67	UJ	0.92	UJ	na	0.22	UJ	0.17	UJ	na
Dibenzo[a,h]anthracene	0.5	U	1.2	U	na	0.7	UJ	1.1	UJ	na	0.098	UJ	0.15	UJ	na
Indeno[1,2,3-cd]pyrene	0.28	U	0.54	U	na	0.67	UJ	0.93	UJ	na	0.027	UJ	0.09	UJ	na
Benzo[g,h,i]perylene	0.3	U	0.63	U	na	0.33	UJ	0.82	UJ	na	0.037	UJ	0.073	UJ	na

NOTE: RPD - relative percent difference
NQ - not quantifiable
na - not applicable

Table C-8. Detection limits (µg/kg) achieved for the analysis of PAH compounds

Chemical	Composite No.																	
	1	1-D	2	3	4	5	6	7	8	8-D	9	10	11	12	13	14	15	15-D
Naphthalene	0.34[b]	NQ	0.31[b]	0.44[b]	0.95[b]	1.1[b]	NQ	1.8[b]	1.8[b]	5.5[b]	1.8[b]	2.7[b]	0.16	0.099	0.23	0.059	0.024	0.077
Acenaphthylene	0.16	0.39[b]	0.62[b]	0.49[b]	0.31[b]	0.59[b]	0.38[b]	1.4[a]	1.8[a]	1.4[a]	0.7[a]	0.98[a]	0.071	0.27	0.13	0.049	0.062	0.057
Acenaphthene	0.17	0.67[a]	0.39[b]	0.45[b]	0.4[b]	0.62[b]	0.15	1.5[a]	1.9[a]	1.5[a]	0.74[b]	1[a]	0.17	0.081	0.13	0.1	0.081	0.042
Fluorene	0.18	0.35	0.35[b]	0.41[b]	0.2	0.61[b]	0.62[a]	1.5[a]	1.9[a]	1.5[a]	0.72[a]	1[a]	0.071	0.071	0.21	0.12	0.025	0.016
Phenanthrene	0.14	0.14	0.28	0.3	0.32[b]	0.66[b]	0.17	0.65[b]	0.78[b]	0.83[b]	0.34[b]	0.62[b]	0.14	0.18	0.3	0.23	0.039	0.06
Anthracene	0.24	0.37[b]	0.31[b]	0.22	0.41[a]	0.72[a]	0.23	0.71[a]	0.86[a]	0.92[a]	0.37[b]	0.68[a]	0.3	0.14	0.68[a]	0.15	0.073	0.07
Fluoranthene	0.16	0.36[b]	0.38[b]	0.41[b]	0.31[b]	0.89[a]	0.16	0.2	0.56[a]	0.74[a]	0.65[a]	0.31[b]	0.094	0.12	0.16	0.2	0.041	0.052
Pyrene	0.19	0.44[b]	0.34[b]	0.44[b]	0.33[b]	0.88[b]	0.17	0.2	0.56[b]	0.73[a]	0.64[b]	0.3	0.13	0.082	0.12	0.11	0.042	0.053
Benz[a]anthracene	0.16	0.24	0.52[a]	0.4[b]	0.36[a]	0.59[a]	0.17	0.2	0.57[a]	0.66[a]	0.81[a]	0.31[a]	0.049	0.07	0.2	0.078	0.03	0.035
Chrysene	0.15	0.35[a]	0.4[b]	0.69[b]	0.31[b]	0.61[a]	0.15	0.21	0.59[a]	0.69[a]	0.84[a]	0.32[a]	0.078	0.062	0.19	0.09	0.031	0.098
Benzo[b,j,k]fluoranthenes	0.38[a]	0.5[a]	0.85[a]	1.2[b]	0.73[a]	0.56[a]	1.1[a]	0.27	0.54[a]	0.78[a]	0.47[a]	0.56[a]	1.3[a]	0.066	0.89[a]	0.063	0.048	0.15
Benzo[e]pyrene	0.32[a]	0.48[a]	0.81[a]	1.4[b]	0.72[a]	0.58[a]	1.1[a]	0.28	0.56[a]	0.82[a]	0.49[a]	0.58[a]	1.3[a]	0.069	3.6[a]	0.18	0.095	0.11
Benzo[a]pyrene	0.47[a]	0.7[a]	1.2[a]	1.2[b]	1.1[a]	0.61[a]	1.4[a]	0.3	0.59[a]	0.85[a]	0.51[a]	0.6[a]	1.4[a]	0.11	0.88[a]	0.17	0.11	0.13
Perylene	0.75[a]	0.98[a]	0.72[b]	0.78	0.81[a]	0.69[a]	1.1[a]	0.33[a]	0.67[a]	0.92[a]	0.54[a]	0.61[a]	2[a]	0.11	0.76[a]	0.22	0.22	0.17
Dibenzo[a,h]anthracene	0.5[a]	1.2[a]	0.47[a]	0.97[a]	0.4[a]	0.75[a]	0.28	0.72[a]	0.7	1.1[a]	0.43[a]	1.1[a]	0.089	0.089	0.064	0.091	0.098	0.15
Indeno[1,2,3-cd]pyrene	0.28	0.54[a]	0.4[b]	1.9[b]	0.34[a]	0.48[a]	0.31[a]	0.63[a]	0.67[a]	0.93[a]	0.45[a]	0.97[a]	0.041	0.036	0.043	0.034	0.027	0.09
Benzo[g,h,i]perylene	0.3	0.63[a]	0.36[b]	1.1[b]	0.25	0.42[a]	0.22	0.56[a]	0.33	0.82[a]	0.4[a]	0.86[a]	0.036	0.045	0.026	0.024	0.037	0.073

NOTE: D - duplicate
NQ - not quantifiable

[a] Detection limit exceeded the data quality objective of 0.3 ug/kg.

[b] Detection limit exceeded the data quality objective of 0.3 ug/kg; however, the measured concentration exceeded this concentration.

samples had detection limits for three or more PAHs that exceeded 0.3 µg/kg, the upper detection limits established as a DQO for PAHs in this study. Overall, 56 percent of PAH analyses exceeded a detection limit of 0.3 µg/kg. The quality of the data is impacted only when a detected quantity was not measured. This occurred in 37 percent of the PAH analyses.

Completeness

Completeness is the percentage of valid results obtained as compared to the total number of samples taken for a parameter. A completeness of 90 percent was established as a DQO for the analysis of PAHs in this study (EVS 1999). Sixty-eight percent of the PAH data were qualified as estimates due to the exceedance of extract holding times, low surrogate recovery, or failure to meet all method quantification criteria. Naphthalene could not be quantified due to low recoveries and matrix interferences in two samples. All data qualified as estimates were considered to be valid and of acceptable quality for this risk assessment. Ninety nine percent of the PAH data were used to assess potential human health risk in this study.

PESTICIDES AND PCB AROCLORS

Organochlorine pesticides and PCB Aroclors were measured using Axys Method CL-T-03, Version 3. Sample extracts were spiked with a suite of isotopically labeled surrogate standards (^{13}C-hexachlorobenzene, ^{13}C-gamma HCH, ^{13}C-p,p'-DDE, ^{13}C-p,p'-DDT, ^{13}C-PCB 101, ^{13}C-PCB 180, ^{13}C-PCB 209), split into two fractions on Florosil, and spiked with an isotopically labeled recovery standard just prior to instrumental analysis. One fraction (F1/F2) was analyzed separately by high resolution gas chromatography/low resolution mass spectrometry (HRGC/LRMS). The other fraction (F3/F4) was analyzed by high resolution gas chromatography/ECD detection (HRGC/ECD). Target concentrations were determined by the isotope dilution or internal standard method.

Holding Times

A one-year holding time for tissue samples and a 40-day holding time for extracts stored in the dark at –20°C were established as DQOs for the analysis of pesticides and PCB Aroclors in this study (EVS 1999). All analyses met these holding times (Table C-9).

Table C-9. Extraction and analysis holding times for pesticide/Aroclor analyses

Composite No.	Species	Sample Type	Collection Date[a]	Extraction Date	Analysis Date	Extraction Holding Time (days)	Analysis Holding Time (days)
1	Sucker	F	8/11/1999	9/11/1999	9/19/1999	31	39
2	Sucker	WB-F	8/11/1999	9/11/1999	9/19/1999	31	39
3	Carp	WB	8/12/1999	9/11/1999	9/19/1999	30	38
4	Carp	WB	8/12/1999	9/11/1999	9/19/1999	30	38
5	Carp	WB	8/18/1999	9/16/1999	9/20/1999	24	33
6	Bass	F	8/12/1999	9/11/1999	9/19/1999	30	38
7	Bass	F	8/11/1999	9/11/1999	9/19/1999	31	39
8	Carp	F	8/14/1999	9/16/1999	9/20/1999	33	37
9	Carp	WB-F	8/14/1999	9/16/1999	9/20/1999	33	37
10	Pikeminnow	F	8/13/1999	9/16/1999	10/10/1999	34	58
11	Pikeminnow	WB-F	8/13/1999	9/16/1999	9/21/1999	34	39
12	Sucker	WB	8/15/1999	9/16/1999	9/21/1999	32	37
13	Pikeminnnow	WB	8/15/1999	9/11/1999	9/20/1999	27	36
14	Carp	WB	8/16/1999	9/16/1999	9/21/1999	31	36
15	Pikeminnnow	WB	8/16/1999	9/16/1999	9/21/1999	31	36

NOTE: F - fillet with skin
WB - whole body
WB-F - whole body minus the fillets

[a] First date of collection for the individual fish comprising the composite sample.

Accuracy

Accuracy was assessed by calculating the percent recovery of spiked isotope-surrogate standards (Table C-10). All percent recoveries were within the DQO limits of 30-140 percent. The average percent recovery for all surrogate standards and samples analyzed in this study was 78 percent. The concentrations of all target congeners were corrected for the percent recovery of the labeled surrogate standards.

Table C-10. Matrix spike percent recovery results for pesticide/PCB labeled surrogate standards

Labeled Surrogate Standards	Composite No.							
	1	2	3	4	5	6	7	8
^{13}C-Hexachlorobenzene	82	39	66	63	66	64	74	72
^{13}C-gamma HCH	84	37	62	58	60	63	75	72
^{13}C-p,p'-DDE	57	45	100	100	120	72	83	150
^{13}C-p,p'-DDT	44	28	48	48	65	43	52	60
^{13}C-PCB 101	72	36	74	75	88	61	75	91
^{13}C-PCB 180	50	30	66	70	100	49	57	68
^{13}C-PCB 209	42	31	56	66	96	57	66	71
d4-alpha-endosulphan	60	100	96	80	120	76	67	78

Labeled Surrogate Standards	Composite No.							
	9	9 Duplicate	10	11	12	13	14	15
^{13}C-Hexachlorobenzene	74	64	58	72	72	50	45	86
^{13}C-gamma HCH	75	61	71	70	71	47	52	100
^{13}C-p,p'-DDE	150	140	110	120	120	80	120	160
^{13}C-p,p'-DDT	71	66	80	63	88	42	62	74
^{13}C-PCB 101	100	94	91	93	92	62	85	110
^{13}C-PCB 180	90	88	87	85	85	60	83	92
^{13}C-PCB 209	85	93	84	99	77	60	80	110
d4-alpha-endosulphan	130	110	95	120	130	80	120	95

Precision

Precision was assessed by analyzing one laboratory duplicate of Composite 9 (Table C-11). Three chemicals (alpha-HCH, beta-HCH, aldrin) had RPD percentages that exceeded the DQO for this study of 50 percent. The concentrations of beta HCH in these tissue samples were near their detection limits (<5 times the detection limit), which may account for the higher variability of the analyses. The overall average precision for all pesticide and Aroclors analyzed in these two samples was 24 percent.

Table C-11. Laboratory duplicate analyses for pesticides and Aroclors

	Composite 9		Composite 9-dup		
Chemical	Conc. (µg/kg)	Qual.	Conc. (µg/kg)	Qual.	RPD ()
Hexachlorobenzene	5.1		5.6		9
Alpha HCH	0.75		0.31		83
Beta HCH	0.38		0.22		53
Gamma HCH	1.6		1.8		12
Heptachlor	0.22	U	0.1	U	na
Aldrin	5.2		2.4		74
Oxychlordane	2.2		3.2		37
Trans-chlordane	1.8		2		11
Cis-chlordane	4.2		4.9		15
o,p'-DDE	0.5		0.54		8
p,p'-DDE	380		380		0
Trans-nonachlor	9.7		11		13
Cis-nonachlor	3.7		4.3		15
o,p'-DDD	1.8		2		11
p,p'-DDD	17		20		16
o,p'-DDT	2.2		2.2		0
p,p'-DDT	2.8		2.1		29
Mirex	0.21		0.25		17
Heptachlor epoxide	0.4		0.34		16
Alpha-endosulfan (I)	0.66		0.67		2
Dieldrin	4.4		4.2		5
Endrin	0.05	U	0.03	U	na
Methoxychlor	0.12	U	0.07	U	na
Aroclor 1242	6.6		6.5		2
Aroclor 1254	82		91		10
Aroclor 1260	65		69		6

NOTE: RPD - relative percent difference
na - not applicable

Detection Limits

Table C-12 shows the sample detection limits achieved for the composite samples analyzed during this study. The detection limits established as DQOs for pesticides in this study ranged from 0.1 to 2 µg/kg (EVS 1999). The analysis of all samples except Composite 1 (largescale sucker fillet) and Composite 10 (northern pikeminnow fillet) met the DQOs for detection limits. For Composite 10, the sample detection limit of oxychlordane (2.9 µg/kg) exceeded the DQO of 2.0 µg/kg. For Composite 1, 13 of the 23 pesticides analyzed had sample detection limits that exceed the DQO of 2.0 µg/kg. Overall, 4 percent of pesticide analyses exceeded the detection limits established as DQOs. The quality of this data is impacted when a detected quantity was not measured. This occurred in 4 percent of the pesticide analyses.

The detection limit established as DQOs for PCB Aroclors in this study was 2.0 µg/kg (EVS 1999). Overall, 16 percent of PCB Aroclor analyses exceeded the detection limit of 2.0 µg/kg. The quality of the PCB Aroclor data is impacted when a detected quanitity was not measured. This occurred in 8 percent of the PCB Aroclor analyses.

Table C12. Detection limits (µg/kg) achieved for the analysis of pesticide and Aroclor compounds

	Composite No.							
Analyte	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Hexachlorobenzene	2	0.05	0.02	0.01	0.02	0.02	0.04	0.03
Alpha HCH	6.2[a]	0.41	0.41	0.13	0.09	0.11	0.13	0.11
Beta HCH	8.7[a]	0.58	0.57	0.18	0.12	0.15	0.19	0.15
Gamma HCH	5[a]	0.33	0.33	0.11	0.07	0.08	0.11	0.09
Heptachlor	17[a]	0.37	0.2	0.17	0.25	0.23	0.31	0.26
Aldrin	3.6[a]	0.26	0.31	0.06	0.11	0.08	0.09	0.07
Oxychlordane	27[a]	2	1.4	0.81	0.3	0.79	0.59	0.35
Trans-chlordane	2.7[a]	0.14	0.03	0.02	0.06	0.06	0.06	0.26
Cis-chlordane	2.3[a]	0.12	0.03	0.01	0.05	0.05	0.05	0.22
o,p'-DDE	3.2[a]	0.35	0.27	0.23	0.19	0.06	0.03	0.05
p,p'-DDE	0.12	0.44	0.22	0.21	0.04	0.05	0.02	0.06
Trans-nonachlor	3[a]	0.12	0.08	0.11	0.11	0.04	0.06	0.07
Cis-nonachlor	2.1[a]	0.08	0.06	0.08	0.08	0.03	0.04	0.05
o,p'-DDD	1.2	0.09	0.11	0.05	0.09	0.01	0.02	0.02
p,p'-DDD	0.027	0.09	0.14	0.13	0.21	0.01	0.02	0.02
o,p'-DDT	2.5[a]	0.09	0.12	0.06	0.11	0.05	0.03	0.07
p,p'-DDT	3.1[a]	0.11	0.15	0.08	0.14	0.06	0.03	0.08
Mirex	1.6	0.07	0.07	0.06	0.03	0.04	0.02	0.04
Heptachlor epoxide	0.03	0.02	0.006	0.01	0.02	0.01	0.007	0.02
Alpha-endosulphan (I)	0.02	0.02	0.007	0.01	0.02	0.01	0.01	0.03
Dieldrin	0.42	0.01	0.005	0.009	0.06	0.008	0.006	0.02
Endrin	0.02	0.03	0.01	0.02	0.14	0.02	0.01	0.05
Methoxychlor	0.02	0.05	0.02	0.03		0.03	0.02	0.13
Aroclor 1242	30[a]	2.5[b]	2.2[b]	0.81	1.7	0.66	0.99	0.6
Aroclor 1254	63[a]	7.2[b]	0.49	1.2	3.2[b]	1.3	0.75	1.5
Aroclor 1260	46[a]	1.2	0.5	0.51	0.29	1.2	1.4	1.1

Table C-12, continued

	Composite							
Analyte	9	9 Duplicate	10	11	12	13	14	15
Hexachlorobenzene	0.02	0.01	0.04	0.01	0.01	0.02	0.02	0.01
Alpha HCH	0.11	0.04	0.54	0.05	0.08	0.32	0.1	0.04
Beta HCH	0.16	0.06	0.69	0.06	0.11	0.44	0.13	0.06
Gamma HCH	0.09	0.03	0.38	0.04	0.06	0.25	0.08	0.04
Heptachlor	0.22	0.1	0.24	0.09	0.16	0.27	0.14	0.17
Aldrin	0.37	0.24	0.07	0.1	0.07	0.23	0.05	0.03
Oxychlordane	0.75	0.2	2.9[a]	0.17	0.32	1.7	0.46	0.29
Trans-chlordane	0.06	0.04	0.02	0.04	0.04	0.05	0.06	0.05
Cis-chlordane	0.05	0.04	0.02	0.04	0.04	0.04	0.05	0.04
o,p'-DDE	0.18	0.03	0.1	0.02	0.12	0.09	0.11	0.03
p,p'-DDE	0.24	0.3	0.09	0.33	0.33	0.16	0.24	0.2
Trans-nonachlor	0.11	0.12	0.02	0.1	0.07	0.03	0.15	0.05
Cis-nonachlor	0.08	0.08	0.01	0.07	0.05	0.02	0.1	0.04
o,p'-DDD	0.14	0.08	0.12	0.06	0.08	0.04	0.08	0.01
p,p'-DDD	0.32	0.33	0.01	0.21	0.17	0.04	0.16	0.01
o,p'-DDT	0.16	0.11	0.07	0.06	0.04	0.05	0.05	0.04
p,p'-DDT	0.2	0.13	0.05	0.08	0.05	0.07	0.06	0.05
Mirex	0.1	0.08	0.07	0.03	0.03	0.04	0.03	0.02
Heptachlor epoxide	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.03
Alpha-endosulphan (I)	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.04
Dieldrin	0.02	0.01	0.01	0.01	0.01	0.009	0.01	0.03
Endrin	0.05	0.03	0.03	0.03	0.03	0.02	0.03	0.07
Methoxychlor	0.12	0.07	0.06	0.07	0.06	0.03	0.06	0.15
Aroclor 1242	0.8	0.82	3.4[a]	0.55	0.69	0.83	0.73	0.33
Aroclor 1254	1.4	1.8	1.3	1.9	0.41	1.5	0.46	1.2
Aroclor 1260	0.78	0.37	0.52	0.23	0.32	1	0.28	0.63

[a] Detection limit exceeded the data quality objective of 2 µg/kg.

[b] Detection limit exceeded the data quality objective of 2 ug/kg; however, the measured concentration exceeded this concentration.

Completeness

Completeness is the percentage of valid results obtained as compared to the total number of samples taken for a parameter. A completeness of 90 percent was established as a DQO for this study (EVS 1999). Nineteen percent of the pesticide data were qualified as estimates due to the exceedance of extract holding times, low surrogate recovery, or failure to meet all method quantification criteria. All analyses of pesticides were considered to be valid and of acceptable quality for this risk assessment.

Twenty-five percent of the PCB Aroclor data were qualified as estimates due to the exceedance of extract holding times, low surrogate recovery, or failure to meet all method quantification criteria. All analyses of PCB Aroclor were considered to be valid and of acceptable quality for this risk assessment.

PCB Congeners

USEPA Method 1668 was used to measure tissue concentrations of 14 PCB congeners in 15 composite samples. The high resolution GC/MS analysis was conducted using a Micromass Autospec Ultima high resolution mass spectrometer (MS) equipped with a HP 5890 gas chromatograph (GC) with a CTC autosampler and an Alpha data system. Project samples were extracted according to Method 1668. The final volume of sample extracts was 20 µl; 1 µl was injected onto a SPB-Octyl GC column. A second run was performed on a DB-1 column to separate PCB 156 and PCB 157 which coelute on the SPB-octyl column.

Holding Times

A one-year holding time for tissue samples and a one year holding for extracts stored in the dark at –20°C was established as data quality objectives (DQOs) for this study (EVS 1999). All analyses met these holding times (Table C-13).

Table C-13. Extraction and analysis holding times for PCB congener analyses

Composite No.	Species	Sample Type	Collection Date*	Extraction Date	Analysis Date	Extraction Holding Time (days)	Analysis Holding Time (days)
1	Sucker	F	8/11/1999	10/10/1999	10/20/1999	60	70
2	Sucker	WB-F	8/11/1999	10/10/1999	10/20/1999	60	70
3	Carp	WB	8/12/1999	10/4/1999	10/19/1999	53	68
4	Carp	WB	8/12/1999	10/10/1999	10/20/1999	59	69
5	Carp	WB	8/18/1999	10/10/1999	10/20/1999	47	62
6	Bass	F	8/12/1999	10/4/1999	10/19/1999	53	68
7	Bass	F	8/11/1999	10/10/1999	10/20/1999	60	70
8	Carp	F	8/14/1999	10/10/1999	10/20/1999	57	67
9	Carp	WB-F	8/14/1999	10/9/1999	10/20/1999	56	67
10	Pikeminnow	F	8/13/1999	10/10/1999	10/20/1999	58	68
11	Pikeminnow	WB-F	8/13/1999	10/4/1999	10/19/1999	52	67
12	Sucker	WB	8/15/1999	10/4/1999	10/19/1999	50	65
13	Pikeminnnow	WB	8/15/1999	10/4/1999	10/19/1999	50	65
14	Carp	WB	8/16/1999	10/4/1999	10/19/1999	49	64
15	Pikeminnnow	WB	8/16/1999	10/4/1999	10/23/1999	49	68

NOTE: F - fillet with skin
WB - whole body
WB-F - whole body minus the fillets

* First date of collection for the individual fish comprising the composite sample.

Accuracy

Accuracy was assessed by calculating the percent recovery of spiked isotope-labeled congeners in accordance with Method 1668 (Table C-14). The recoveries of all congeners were within the labeled recovery ranges specified by Method 1668. The average percent recovery for all congeners and samples analyzed in this study was 66 percent. The concentrations of all target congeners were corrected for the percent recovery of the labeled congeners in accordance with Method 1668.

Table C-14. Matrix spike percent recovery results for labeled PCB congener surrogate standards

Labeled Surrogate Standards	Composite No. 1	2	3	4	5	6	7	8
^{13}C-PCB 77	66	56	70	64	64	92	56	78
^{13}C-PCB 123	61	45	62	55	56	80	55	62
^{13}C-PCB 118	66	61	67	81	88	83	65	87
^{13}C-PCB 114	62	40	61	50	53	84	59	62
^{13}C-PCB 105	64	46	66	55	72	88	58	60
^{13}C-PCB 126	64	40	60	48	48	82	55	58
^{13}C-PCB 167	61	43	67	47	59	66	62	57
^{13}C-PCB 156/157	62	41	66	46	56	64	61	53
^{13}C-PCB 169	65	39	62	43	52	66	57	53
^{13}C-PCB 180	85	69	77	93	100	66	99	110
^{13}C-PCB 170	nr	nr	69	nr	nr	57	nr	nr
^{13}C-PCB 189	69	44	71	55	54	65	74	67

Labeled Surrogate Standards	Composite No. 9	10	11	12	13	14	15
^{13}C-PCB 77	77	70	73	80	83	71	63
^{13}C-PCB 123	68	61	62	73	71	61	59
^{13}C-PCB 118	86	79	71	79	84	74	70
^{13}C-PCB 114	61	61	60	70	69	58	57
^{13}C-PCB 105	79	66	67	69	77	64	61
^{13}C-PCB 126	56	60	60	63	69	55	55
^{13}C-PCB 167	62	61	61	61	69	61	54
^{13}C-PCB 156/157	62	60	62	62	68	63	54
^{13}C-PCB 169	54	60	59	59	61	62	52
^{13}C-PCB 180	100	100	nr	91	100	nr	nr
^{13}C-PCB 170	nr	nr	nr	71	75	nr	nr
^{13}C-PCB 189	58	73	78	82	81	81	81

NOTE: nr- not reported

Detection Limits

Sample detection limits for the PCB congeners analyzed in this study ranged from 0.14 to 46 ng/kg for this study (Table C-15). The detection limit of 5.0 ng/kg established as a DQO for this study was exceeded for eight of the PCB congeners analyzed. Overall, 36 percent of the congener analyses exceeded a detection limit of 5.0 ng/kg. The quality of the data is impacted only when a detected quantity was not measured. This occurred in 1 percent of the PCB congener analyses.

Table C-15. Detection limits (ng/kg) achieved for the analysis of PCB congeners

Chemical	Composite No. 1	2	3	4	5	6	7	8
PCB 77	2.5	17[b]	4.2	13[b]	21[b]	2.7	4	8.3[b]
PCB 123	3	11[b]	4.6	11[b]	17[b]	3.3	4.7	7.3[b]
PCB 118	3	19[b]	19[b]	20[b]	40[b]	3.3	4	11[b]
PCB 114	3.3	13[b]	5.1[b]	13[b]	19[b]	3.4	4.8	7.9[b]
PCB 105	2.8	10[b]	4.2	10[b]	46[b]	2.9	4.3	7.2[b]
PCB 126	2.9	12[b]	5	12[b]	20[a]	0.67	4.7	7.7[b]
PCB 167	0.99	4.6	4.3	3.7	3.3	0.67	0.82	2.9
PCB 156/157	1.3	6.6[b]	6.3[b]	5.1[b]	4.8	1	1.2	4.5
PCB 169	0.94	5.1[b]	5.2[b]	3.9	3.9	0.74	0.92	3.3
PCB 180/193	0.11	0.12	0.062	0.39	0.38	0.22	0.12	0.21
PCB 170	0.15	0.27	0.15	0.32	0.4	0.28	0.18	0.4
PCB 189	0.32	0.97	0.74	1	1.3	0.39	0.36	0.58

Chemical	Composite No. 9	10	11	12	13	14	15
PCB 77	14[b]	3.7	16[b]	4.1	3	11[b]	7.6[b]
PCB 123	11[b]	5	28[b]	4.4	4.9	11[b]	8.3[b]
PCB 118	24[b]	11[b]	28[b]	3.7	22[b]	18[b]	12[b]
PCB 114	13[b]	5.6[b]	29[b]	4.4	5.4[b]	12[b]	9[b]
PCB 105	24[b]	4.	24[b]	4.2	4.4	9.6[b]	7.8[b]
PCB 126	13[b]	5.1[b]	7.6[b]	4.7	5.2[b]	4.1	2.5
PCB 167	2	1.6	3.7	4.7	3.6	2.6	4
PCB 156/157	2.7	2.2	5.4[b]	7[b]	5.2[b]	3.7	5.6[b]
PCB 169	2.2	1.7	4.4	5.3[b]	4.7	3.1	0.5
PCB 180/193	0.11	0.16	0.034	0.019	0.067	0.59	0.02
PCB 170	0.41	0.24	0.24	0.47	0.14	0.5	0.32
PCB 189	1	0.5	1.4	1.1	1.2	0.89	0.58

[a] Detection limit exceeded the data quality objective of 5.0 ug/kg.

[b] Detection limit exceeded the data quality objective of 5.0 ug/kg; however, the measured concentration exceeded this concentration.

Completeness

Completeness is the percentage of valid results obtained as compared to the total number of samples taken for a parameter. A completeness of 90 percent was established as a DQO for this study (EVS 1999). Seven percent of the PCB congener data were qualified as estimates due to the exceedance of extract holding times, low surrogate recovery, or failure to meet all method quantification criteria. All analyses of PCB congeners were considered to be valid and of acceptable quality for this risk assessment.

DIOXINS AND FURANS

USEPA Method 1613B was used to measure tissue concentrations of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzo-*p*-furans (PCDDs/PCDFs) in 15 composite samples. The high resolution GC/MS analysis was conducted using a Micromass Autospec Ultima high resolution mass spectrometer (MS) equipped with a HP 5890 gas chromatograph (GC) with a CTC autosampler and an Alpha data system. Project samples were extracted according to Method 1613B. The final volume of sample extracts was 20 µl; 1 µl was injected onto the GC column. Isomer specificity for 2,3,7,8-TCDF cannot be confirmed using the primary DB-5 capillary column specified for Method 1613B. All samples in which this isomer was detected on the DB-5 column underwent confirmatory analysis using a secondary DB-225 column. The concentrations reported for 2,3,7,8-TCDF in this report are from the secondary DB-225 column.

Holding Times

The one year holding times for extracts and analysis recommended for the analysis of tissue samples using Method 1613B (USEPA 1994) were established as DQOs for this study. All analyses met these holding times (Table C-16).

Table C-16. Extraction and analysis holding times for dioxin/furan analyses

Composite No.	Species	Sample Type	Collection Date[a]	Extraction Date	Analysis Date	Extraction Holding Time (days)	Analysis Holding Time (days)
1	Sucker	F	8/11/1999	9/26/1999	10/29/1999	46	79
2	Sucker	WB-F	8/11/1999	9/26/1999	10/28/1999	46	78
3	Carp	WB	8/12/1999	9/26/1999	10/28/1999	45	77
4	Carp	WB	8/12/1999	9/26/1999	10/28/1999	45	77
5	Carp	WB	8/18/1999	9/26/1999	10/28/1999	39	71
6	Bass	F	8/12/1999	11/24/1999	12/10/1999	104	120
7	Bass	F	8/11/1999	9/26/1999	10/28/1999	46	78
8	Carp	F	8/14/1999	9/26/1999	10/28/1999	43	75
9	Carp	WB-F	8/14/1999	9/24/1999	10/28/1999	41	75
10	Pikeminnow	F	8/13/1999	9/24/1999	10/28/1999	42	76
11	Pikeminnow	WB-F	8/13/1999	9/24/1999	10/28/1999	42	76
12	Sucker	WB	8/15/1999	9/24/1999	10/28/1999	40	74
13	Pikeminnnow	WB	8/15/1999	9/24/1999	10/28/1999	40	74
14	Carp	WB	8/16/1999	9/24/1999	10/28/1999	39	73
15	Pikeminnnow	WB	8/16/1999	9/24/1999	10/28/1999	39	73

NOTE: F - fillet with skin
WB - whole body
WB-F - whole body minus the fillets

[a] First date of collection for the individual fish comprising the composite sample.

Accuracy

Accuracy was assessed by calculating the percent recovery of spiked isotope-labeled congeners in accordance with Method 1613B (Table C-17). The recovery of all PCDD/PCDF congeners were within the labeled recovery ranges specified by Method 1613B (USEPA 1994). The average percent recovery for all congeners and samples analyzed in this study was 75 percent. The concentrations of all target congeners were corrected for the percent recovery of the labeled congeners in accordance with Method 1613B.

Table C-17. Matrix spike percent recovery results for labeled dioxin/furan congener surrogate standards

^{13}C Labeled Surrogate Standards	Composite No. 1	2	3	4	5	6	7	8
2,3,7,8-TCDD	81	80	75	66	82	67	85	87
1,2,3,7,8-PeCDD	97	82	97	96	81	81	128	92
1,2,3,4,7,8-HxCDD	84	95	88	82	83	71	88	87
1,2,3,6,7,8-HxCDD	83	89	84	80	82	73	86	84
1,2,3,4,6,7,8-HpCDD	63	75	58	68	62	75	75	80
OCDD	51	64	30	51	48	58	59	67
2,3,7,8-TCDF	73	64	69	72	72	73	82	82
1,2,3,7,8-PeCDF	78	65	69	67	70	81	84	73
2,3,4,7,8-PeCDF	81	63	71	69	68	82	87	72
1,2,3,4,7,8-HxCDF	83	93	89	82	79	76	87	79
1,2,3,6,7,8-HxCDF	81	90	85	79	76	75	85	68
1,2,3,7,8,9-HxCDF	77	81	61	67	77	71	81	80
2,3,4,6,7,8-HxCDF	83	93	78	78	82	77	88	85

^{13}C Labeled Surrogate Standards	Composite No. 9	10	11	12	13	14	15
2,3,7,8-TCDD	90	79	76	68	80	80	72
1,2,3,7,8-PeCDD	105	87	81	89	85	77	81
1,2,3,4,7,8-HxCDD	95	86	81	87	85	78	80
1,2,3,6,7,8-HxCDD	90	81	76	79	83	75	74
1,2,3,4,6,7,8-HpCDD	67	65	65	60	68	59	63
OCDD	53	51	54	44	53	43	52
2,3,7,8-TCDF	84	67	68	63	81	77	65
1,2,3,7,8-PeCDF	78	62	64	66	68	69	62
2,3,4,7,8-PeCDF	83	64	67	77	75	72	73
1,2,3,4,7,8-HxCDF	94	86	81	85	84	81	81
1,2,3,6,7,8-HxCDF	88	81	78	82	81	77	77
1,2,3,7,8,9-HxCDF	85	72	72	71	78	76	72
2,3,4,6,7,8-HxCDF	90	79	79	79	84	78	78

NOTE: nr- not reported

Detection Limits

The use of an ultra-low sensitivity high-resolution mass spectrometer system and the stipulation that Method 1613B be enhanced by measuring a low initial calibration point of 0.1 ng/ml along with the other five calibration standards normally recommended by this method, allowed detection limits ranging from 0.05 to 0.3 ng/kg to be achieved for this study. Table C-18 shows the range of detection limits obtained for each congener. All values are within the DQOs established for this study.

Table C-18. Detection limits (ng/kg) achieved for the analysis of PCB congeners

	Composite No.							
Chemical	1	2	3	4	5	6	7	8
2,3,7,8-TCDD	0.05	0.05	0.1	0.09	0.05	0.09	0.06	0.07
1,2,3,7,8-PeCDD	0.05	0.09	0.07	0.09	0.08	0.1	0.05	0.08
1,2,3,4,7,8-HxCDD	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1,2,3,6,7,8-HxCDD	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1,2,3,7,8,9-HxCDD	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1,2,3,4,6,7,8-HpCDD	0.15	0.15	0.18	0.15	0.15	0.15	0.15	0.15
OCDD	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
2,3,7,8-TCDF	0.05	0.06	0.07	0.05	0.05	0.05	0.05	0.05
1,2,3,7,8-PeCDF	0.05	0.08	0.09	0.11	0.06	0.07	0.05	0.08
2,3,4,7,8-PeCDF	0.05	0.08	0.09	0.11	0.06	0.07	0.05	0.08
1,2,3,4,7,8-HxCDF	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1,2,3,6,7,8-HxCDF	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1,2,3,7,8,9-HxCDF	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

	Composite No.						
Chemical	9	10	11	12	13	14	15
2,3,7,8-TCDD	0.05	0.09	0.05	0.05	0.06	0.06	0.08
1,2,3,7,8-PeCDD	0.07	0.07	0.08	0.06	0.06	0.07	0.1
1,2,3,4,7,8-HxCDD	0.11	0.1	0.1	0.1	0.06	0.1	0.1
1,2,3,6,7,8-HxCDD	0.11	0.1	0.1	0.1	0.1	0.1	0.1
1,2,3,7,8,9-HxCDD	0.11	0.1	0.1	0.1	0.1	0.1	0.1
1,2,3,4,6,7,8-HpCDD	0.15	0.15	0.15	0.15	0.15	0.15	0.15
OCDD	0.3	0.3	0.3	0.3	0.3	0.3	0.3
2,3,7,8-TCDF	0.05	0.07	0.07	0.08	0.06	0.05	0.06
1,2,3,7,8-PeCDF	0.08	0.08	0.07	0.07	0.09	0.06	0.09
2,3,4,7,8-PeCDF	0.08	0.08	0.07	0.07	0.09	0.06	0.09
1,2,3,4,7,8-HxCDF	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1,2,3,6,7,8-HxCDF	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1,2,3,7,8,9-HxCDF	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Completeness

Completeness is the percentage of valid results obtained as compared to the total number of samples taken for a parameter. A completeness of 90 percent was established as a DQO for this study. All analyses of dioxin and furans were considered to be valid and of acceptable quality for this risk assessment.

APPENDIX D

Summary Statistics for Fish Species

Table D-1. Summary statistics for fish species

Species	Sample Type	Chemical	Chemical Group	Number of Samples	Detection Frequency	Minimum (ug/kg)	Maximum (ug/kg)	Average (ug/kg)	Standard Deviation
Bass	Fillet	2,3,7,8-TCDD	Dioxin/Furans	2	2	0.00010	0.00014	0.00012	0.000028
Bass	Fillet	1,2,3,7,8-PeCDD	Dioxin/Furans	2	2	0.00010	0.00011	0.00011	0.0000071
Bass	Fillet	1,2,3,4,7,8-HxCDD	Dioxin/Furans	2	0	0.00010	0.00010	0.00010	0.00
Bass	Fillet	1,2,3,6,7,8-HxCDD	Dioxin/Furans	2	0	0.00010	0.00010	0.00010	0.00
Bass	Fillet	1,2,3,7,8,9-HxCDD	Dioxin/Furans	2	0	0.00010	0.00010	0.00010	0.00
Bass	Fillet	1,2,3,4,6,7,8-HpCDD	Dioxin/Furans	2	0	0.00015	0.00015	0.00015	0.00
Bass	Fillet	OCDD	Dioxin/Furans	2	0	0.00030	0.00030	0.00030	0.00
Bass	Fillet	2,3,7,8-TCDF	Dioxin/Furans	2	2	0.00014	0.00017	0.00016	0.000021
Bass	Fillet	1,2,3,7,8-PeCDF	Dioxin/Furans	2	0	0.000050	0.000070	0.000060	0.000014
Bass	Fillet	2,3,4,7,8-PeCDF	Dioxin/Furans	2	1	0.000070	0.000080	0.000058	0.000032
Bass	Fillet	1,2,3,4,7,8-HxCDF	Dioxin/Furans	2	0	0.00010	0.00010	0.00010	0.00
Bass	Fillet	1,2,3,6,7,8-HxCDF	Dioxin/Furans	2	0	0.00010	0.00010	0.00010	0.00
Bass	Fillet	1,2,3,7,8,9-HxCDF	Dioxin/Furans	2	0	0.00010	0.00010	0.00010	0.00
Bass	Fillet	2,3,4,6,7,8-HxCDF	Dioxin/Furans	2	0	0.00010	0.00010	0.00010	0.00
Bass	Fillet	1,2,3,4,6,7,8-HpCDF	Dioxin/Furans	2	0	0.00015	0.00015	0.00015	0.00
Bass	Fillet	1,2,3,4,7,8,9-HpCDF	Dioxin/Furans	2	0	0.00015	0.00015	0.00015	0.00
Bass	Fillet	OCDF	Dioxin/Furans	2	0	0.00030	0.00030	0.00030	0.00
Bass	Fillet	Antimony	Trace Metals	2	0	1.0	1.0	1.0	0.00
Bass	Fillet	Arsenic	Trace Metals	2	2	80	110	95	21
Bass	Fillet	Total Inorganic Arsenic	Trace Metals	2	1	3.0	5.0	3.3	2.5
Bass	Fillet	Beryllium	Trace Metals	2	0	1.0	1.0	1.0	0.00
Bass	Fillet	Cadmium	Trace Metals	2	0	10	10	10	0.00
Bass	Fillet	Chromium	Trace Metals	2	2	190	190	190	0.00
Bass	Fillet	Copper	Trace Metals	2	2	680	950	820	190
Bass	Fillet	Lead	Trace Metals	2	0	5.0	5.0	5.0	0.00
Bass	Fillet	Mercury	Trace Metals	2	2	330	420	380	58
Bass	Fillet	Nickel	Trace Metals	2	2	100	130	120	21
Bass	Fillet	Silver	Trace Metals	2	0	10	10	10	0.00
Bass	Fillet	Thallium	Trace Metals	2	0	2.0	2.0	2.0	0.00
Bass	Fillet	Zinc	Trace Metals	2	2	6,200	9,000	7,600	2,000
Bass	Fillet	Aroclor 1242	PCB Aroclors	2	2	1.2	1.3	1.3	0.071
Bass	Fillet	Aroclor 1254	PCB Aroclors	2	2	13	15	14	1.4
Bass	Fillet	Aroclor 1260	PCB Aroclors	2	2	11	11	11	0.00
Bass	Fillet	33'44'-TeCB	PCB Congeners	2	2	0.012	0.014	0.013	0.0014
Bass	Fillet	233'44'-PeCB	PCB Congeners	2	2	0.42	0.47	0.45	0.035
Bass	Fillet	2344'5-PeCB	PCB Congeners	2	2	0.039	0.042	0.041	0.0021
Bass	Fillet	23'44'5-PeCB	PCB Congeners	2	2	1.3	1.6	1.5	0.21
Bass	Fillet	2'344'5-PeCB	PCB Congeners	2	2	0.033	0.033	0.033	0.00
Bass	Fillet	33'44'5-PeCB	PCB Congeners	2	1	0.0037	0.0047	0.0030	0.00095
Bass	Fillet	233'44'5-HxCB	PCB Congeners	2	2	0.21	0.25	0.23	0.028
Bass	Fillet	23'44'55'-HxCB	PCB Congeners	2	2	0.080	0.087	0.084	0.0049
Bass	Fillet	33'44'55'-HxCB	PCB Congeners	2	2	0.0029	0.0047	0.0038	0.0013
Bass	Fillet	22'33'44'5-HpCB	PCB Congeners	2	2	0.34	0.37	0.36	0.021
Bass	Fillet	22'344'55'-HpCB	PCB Congeners	2	2	0.95	0.98	0.97	0.021
Bass	Fillet	233'44'55'-HpCB	PCB Congeners	2	2	0.012	0.017	0.015	0.0035
Bass	Fillet	Aldrin	Pesticides	2	0	0.080	0.090	0.085	0.0071
Bass	Fillet	alpha HCH	Pesticides	2	0	0.11	0.13	0.12	0.014
Bass	Fillet	alpha-Endosulfan (I)	Pesticides	2	0	0.010	0.010	0.010	0.00
Bass	Fillet	beta HCH	Pesticides	2	0	0.15	0.19	0.17	0.028
Bass	Fillet	cis-Chlordane	Pesticides	2	2	0.21	0.22	0.22	0.0071
Bass	Fillet	cis-Nonachlor	Pesticides	2	2	0.30	0.36	0.33	0.042
Bass	Fillet	o,p'-DDD	Pesticides	2	2	0.12	0.14	0.13	0.014
Bass	Fillet	o,p'-DDE	Pesticides	2	2	0.080	0.090	0.085	0.0071
Bass	Fillet	o,p'-DDT	Pesticides	2	2	0.21	0.22	0.22	0.0071
Bass	Fillet	p,p'-DDD	Pesticides	2	2	1.0	1.3	1.2	0.21
Bass	Fillet	p,p'-DDE	Pesticides	2	2	14	18	16	2.8
Bass	Fillet	p,p'-DDT	Pesticides	2	2	1.4	1.5	1.5	0.071
Bass	Fillet	Dieldrin	Pesticides	2	2	0.23	0.24	0.24	0.0071
Bass	Fillet	Endrin	Pesticides	2	0	0.010	0.020	0.015	0.0071
Bass	Fillet	gamma HCH	Pesticides	2	2	0.79	0.82	0.81	0.021
Bass	Fillet	Heptachlor	Pesticides	2	0	0.23	0.31	0.27	0.057
Bass	Fillet	Heptachlor Epoxide	Pesticides	2	0	0.0070	0.010	0.0085	0.0021
Bass	Fillet	Hexachlorobenzene	Pesticides	2	2	0.67	0.90	0.79	0.16
Bass	Fillet	Methoxychlor	Pesticides	2	0	0.020	0.030	0.025	0.0071
Bass	Fillet	Mirex	Pesticides	2	2	0.040	0.050	0.045	0.0071
Bass	Fillet	Oxychlordane	Pesticides	2	0	0.59	0.79	0.69	0.14
Bass	Fillet	trans-Chlordane	Pesticides	2	2	0.090	0.13	0.11	0.028
Bass	Fillet	trans-Nonachlor	Pesticides	2	2	1.1	1.1	1.1	0.00
Bass	Fillet	Acenaphthene	PAHs	2	1	0.22	1.5	0.49	0.37
Bass	Fillet	Acenaphthylene	PAHs	2	1	0.76	1.4	0.73	0.042
Bass	Fillet	Anthracene	PAHs	2	0	0.23	0.71	0.47	0.34
Bass	Fillet	Benz[a]anthracene	PAHs	2	0	0.17	0.20	0.19	0.021
Bass	Fillet	Benzo[a]pyrene	PAHs	2	0	0.30	1.4	0.85	0.78
Bass	Fillet	Benzo[e]pyrene	PAHs	2	0	0.28	1.1	0.69	0.58
Bass	Fillet	Benzo[ghi]perylene	PAHs	2	0	0.22	0.56	0.39	0.24
Bass	Fillet	Benzo[b/j/k]fluoranthenes	PAHs	2	0	0.27	1.1	0.69	0.59
Bass	Fillet	Chrysene	PAHs	2	0	0.15	0.21	0.18	0.042
Bass	Fillet	Dibenz[ah]anthracene	PAHs	2	0	0.28	0.72	0.50	0.31

Table D-1. Summary statistics for fish species

Species	Sample Type	Chemical	Chemical Group	Number of Samples	Detection Frequency	Minimum (ug/kg)	Maximum (ug/kg)	Average (ug/kg)	Standard Deviation
Bass	Fillet	Fluoranthene	PAHs	2	2	0.31	0.54	0.43	0.16
Bass	Fillet	Fluorene	PAHs	2	0	0.62	1.5	1.1	0.62
Bass	Fillet	Indeno[1,2,3-cd]pyrene	PAHs	2	0	0.31	0.63	0.47	0.23
Bass	Fillet	Naphthalene	PAHs	2	1	11	11	11	na
Bass	Fillet	Perylene	PAHs	2	0	0.33	1.1	0.72	0.54
Bass	Fillet	Phenanthrene	PAHs	2	2	1.1	2.2	1.7	0.78
Bass	Fillet	Pyrene	PAHs	2	2	0.20	0.33	0.27	0.092
Carp	Fillet	2,3,7,8-TCDD	Dioxin/Furans	1	1	0.00038	0.00038	0.00038	na
Carp	Fillet	1,2,3,7,8-PeCDD	Dioxin/Furans	1	1	0.00042	0.00042	0.00042	na
Carp	Fillet	1,2,3,4,7,8-HxCDD	Dioxin/Furans	1	1	0.00031	0.00031	0.00031	na
Carp	Fillet	1,2,3,6,7,8-HxCDD	Dioxin/Furans	1	1	0.0012	0.0012	0.0012	na
Carp	Fillet	1,2,3,7,8,9-HxCDD	Dioxin/Furans	1	1	0.00010	0.00010	0.00010	na
Carp	Fillet	1,2,3,4,6,7,8-HpCDD	Dioxin/Furans	1	1	0.0021	0.0021	0.0021	na
Carp	Fillet	OCDD	Dioxin/Furans	1	1	0.0019	0.0019	0.0019	na
Carp	Fillet	2,3,7,8-TCDF	Dioxin/Furans	1	1	0.00040	0.00040	0.00040	na
Carp	Fillet	1,2,3,7,8-PeCDF	Dioxin/Furans	1	1	0.00010	0.00010	0.00010	na
Carp	Fillet	2,3,4,7,8-PeCDF	Dioxin/Furans	1	1	0.00029	0.00029	0.00029	na
Carp	Fillet	1,2,3,4,7,8-HxCDF	Dioxin/Furans	1	1	0.00015	0.00015	0.00015	na
Carp	Fillet	1,2,3,6,7,8-HxCDF	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Carp	Fillet	1,2,3,7,8,9-HxCDF	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Carp	Fillet	2,3,4,6,7,8-HxCDF	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Carp	Fillet	1,2,3,4,6,7,8-HpCDF	Dioxin/Furans	1	0	0.00015	0.00015	0.00015	na
Carp	Fillet	1,2,3,4,7,8,9-HpCDF	Dioxin/Furans	1	0	0.00015	0.00015	0.00015	na
Carp	Fillet	OCDF	Dioxin/Furans	1	0	0.00030	0.00030	0.00030	na
Carp	Fillet	Antimony	Trace Metals	1	0	1.0	1.0	1.0	na
Carp	Fillet	Arsenic	Trace Metals	1	1	120	120	120	na
Carp	Fillet	Total Inorganic Arsenic	Trace Metals	1	0	3.0	3.0	3.0	na
Carp	Fillet	Beryllium	Trace Metals	1	0	1.0	1.0	1.0	na
Carp	Fillet	Cadmium	Trace Metals	1	0	10	10	10	na
Carp	Fillet	Chromium	Trace Metals	1	1	230	230	230	na
Carp	Fillet	Copper	Trace Metals	1	1	670	670	670	na
Carp	Fillet	Lead	Trace Metals	1	0	5.0	5.0	5.0	na
Carp	Fillet	Mercury	Trace Metals	1	1	250	250	250	na
Carp	Fillet	Nickel	Trace Metals	1	0	10	10	10	na
Carp	Fillet	Silver	Trace Metals	1	0	10	10	10	na
Carp	Fillet	Thallium	Trace Metals	1	0	2.0	2.0	2.0	na
Carp	Fillet	Zinc	Trace Metals	1	1	30,000	30,000	30,000	na
Carp	Fillet	Aroclor 1242	PCB Aroclors	1	1	3.0	3.0	3.0	na
Carp	Fillet	Aroclor 1254	PCB Aroclors	1	1	36	36	36	na
Carp	Fillet	Aroclor 1260	PCB Aroclors	1	1	32	32	32	na
Carp	Fillet	33'44'-TeCB	PCB Congeners	1	1	0.038	0.038	0.038	na
Carp	Fillet	233'44'-PeCB	PCB Congeners	1	1	1.0	1.0	1.0	na
Carp	Fillet	2344'5-PeCB	PCB Congeners	1	1	0.092	0.092	0.092	na
Carp	Fillet	23'44'5-PeCB	PCB Congeners	1	1	3.8	3.8	3.8	na
Carp	Fillet	2'344'5-PeCB	PCB Congeners	1	1	0.14	0.14	0.14	na
Carp	Fillet	33'44'5-PeCB	PCB Congeners	1	1	0.0089	0.0089	0.0089	na
Carp	Fillet	233'44'5-HxCB	PCB Congeners	1	1	0.60	0.60	0.60	na
Carp	Fillet	23'44'55'-HxCB	PCB Congeners	1	1	0.28	0.28	0.28	na
Carp	Fillet	33'44'55'-HxCB	PCB Congeners	1	1	0.011	0.011	0.011	na
Carp	Fillet	22'33'44'5-HpCB	PCB Congeners	1	1	1.1	1.1	1.1	na
Carp	Fillet	22'344'55'-HpCB	PCB Congeners	1	1	3.0	3.0	3.0	na
Carp	Fillet	233'44'55'-HpCB	PCB Congeners	1	1	0.050	0.050	0.050	na
Carp	Fillet	Aldrin	Pesticides	1	1	0.080	0.080	0.080	na
Carp	Fillet	alpha HCH	Pesticides	1	0	0.11	0.11	0.11	na
Carp	Fillet	alpha-Endosulfan (I)	Pesticides	1	0	0.030	0.030	0.030	na
Carp	Fillet	beta HCH	Pesticides	1	0	0.15	0.15	0.15	na
Carp	Fillet	cis-Chlordane	Pesticides	1	1	2.2	2.2	2.2	na
Carp	Fillet	cis-Nonachlor	Pesticides	1	1	1.7	1.7	1.7	na
Carp	Fillet	o,p'-DDD	Pesticides	1	1	0.81	0.81	0.81	na
Carp	Fillet	o,p'-DDE	Pesticides	1	1	0.18	0.18	0.18	na
Carp	Fillet	o,p'-DDT	Pesticides	1	1	0.92	0.92	0.92	na
Carp	Fillet	p,p'-DDD	Pesticides	1	1	9.7	9.7	9.7	na
Carp	Fillet	p,p'-DDE	Pesticides	1	1	170	170	170	na
Carp	Fillet	p,p'-DDT	Pesticides	1	1	0.92	0.92	0.92	na
Carp	Fillet	Dieldrin	Pesticides	1	1	1.8	1.8	1.8	na
Carp	Fillet	Endrin	Pesticides	1	0	0.050	0.050	0.050	na
Carp	Fillet	gamma HCH	Pesticides	1	1	0.89	0.89	0.89	na
Carp	Fillet	Heptachlor	Pesticides	1	0	0.26	0.26	0.26	na
Carp	Fillet	Heptachlor Epoxide	Pesticides	1	1	0.17	0.17	0.17	na
Carp	Fillet	Hexachlorobenzene	Pesticides	1	1	2.6	2.6	2.6	na
Carp	Fillet	Methoxychlor	Pesticides	1	0	0.13	0.13	0.13	na
Carp	Fillet	Mirex	Pesticides	1	1	0.10	0.10	0.10	na
Carp	Fillet	Oxychlordane	Pesticides	1	1	0.86	0.86	0.86	na
Carp	Fillet	trans-Chlordane	Pesticides	1	1	0.88	0.88	0.88	na
Carp	Fillet	trans-Nonachlor	Pesticides	1	1	3.8	3.8	#N/A	na
Carp	Fillet	Acenaphthene	PAHs	2	0	1.7	1.7	1.7	na
Carp	Fillet	Acenaphthylene	PAHs	2	0	1.6	1.6	1.6	na
Carp	Fillet	Anthracene	PAHs	2	0	0.89	0.89	0.89	na

Table D-1. Summary statistics for fish species

Species	Sample Type	Chemical	Chemical Group	Number of Samples	Detection Frequency	Minimum (ug/kg)	Maximum (ug/kg)	Average (ug/kg)	Standard Deviation
Carp	Fillet	Benz[a]anthracene	PAHs	2	0	0.62	0.62	0.62	na
Carp	Fillet	Benzo[a]pyrene	PAHs	2	0	0.72	0.72	0.72	na
Carp	Fillet	Benzo[e]pyrene	PAHs	2	0	0.69	0.69	0.69	na
Carp	Fillet	Benzo[ghi]perylene	PAHs	2	0	0.58	0.58	0.58	na
Carp	Fillet	Benzo[b/j/k]fluoranthenes	PAHs	2	0	0.66	0.66	0.66	na
Carp	Fillet	Chrysene	PAHs	2	0	0.64	0.64	0.64	na
Carp	Fillet	Dibenz[ah]anthracene	PAHs	2	0	0.90	0.90	0.90	na
Carp	Fillet	Fluoranthene	PAHs	2	0	0.65	0.65	0.65	na
Carp	Fillet	Fluorene	PAHs	2	0	1.7	1.7	1.7	na
Carp	Fillet	Indeno(1,2,3-cd]pyrene	PAHs	2	0	0.80	0.80	0.80	na
Carp	Fillet	Naphthalene	PAHs	2	1	13	13	13	na
Carp	Fillet	Perylene	PAHs	2	0	0.80	0.80	0.80	na
Carp	Fillet	Phenanthrene	PAHs	2	1	1.8	1.8	1.8	na
Carp	Fillet	Pyrene	PAHs	2	1	0.49	0.49	0.49	na
Carp	WB	2,3,7,8-TCDD	Dioxin/Furans	5	5	0.00063	0.0013	0.00082	0.00029
Carp	WB	1,2,3,7,8-PeCDD	Dioxin/Furans	5	5	0.00080	0.0016	0.0011	0.00035
Carp	WB	1,2,3,4,7,8-HxCDD	Dioxin/Furans	5	5	0.00045	0.0013	0.00073	0.00031
Carp	WB	1,2,3,6,7,8-HxCDD	Dioxin/Furans	5	5	0.0018	0.0051	0.0030	0.0013
Carp	WB	1,2,3,7,8,9-HxCDD	Dioxin/Furans	5	5	0.00024	0.00059	0.00034	0.00014
Carp	WB	1,2,3,4,6,7,8-HpCDD	Dioxin/Furans	5	5	0.0037	0.0096	0.0056	0.0024
Carp	WB	OCDD	Dioxin/Furans	5	5	0.0041	0.011	0.0068	0.0027
Carp	WB	2,3,7,8-TCDF	Dioxin/Furans	5	5	0.00069	0.0013	0.00094	0.00024
Carp	WB	1,2,3,7,8-PeCDF	Dioxin/Furans	5	4	0.00011	0.00038	0.00023	0.00012
Carp	WB	2,3,4,7,8-PeCDF	Dioxin/Furans	5	5	0.00047	0.0011	0.00065	0.00024
Carp	WB	1,2,3,4,7,8-HxCDF	Dioxin/Furans	5	5	0.00025	0.00065	0.00037	0.00016
Carp	WB	1,2,3,6,7,8-HxCDF	Dioxin/Furans	5	5	0.00017	0.00040	0.00025	0.000090
Carp	WB	1,2,3,7,8,9-HxCDF	Dioxin/Furans	5	0	0.00010	0.00010	0.00010	0.00
Carp	WB	2,3,4,6,7,8-HxCDF	Dioxin/Furans	5	5	0.00014	0.00026	0.00019	0.000049
Carp	WB	1,2,3,4,6,7,8-HpCDF	Dioxin/Furans	5	3	0.00015	0.0011	0.00043	0.00042
Carp	WB	1,2,3,4,7,8,9-HpCDF	Dioxin/Furans	5	0	0.00015	0.00017	0.00016	0.000010
Carp	WB	OCDF	Dioxin/Furans	5	1	0.00030	0.00030	0.00018	0.000067
Carp	WB	Antimony	Trace Metals	5	2	1.0	1.0	0.70	0.27
Carp	WB	Arsenic	Trace Metals	5	5	130	160	150	11
Carp	WB	Total Inorganic Arsenic	Trace Metals	5	5	3.0	9.0	5.7	2.4
Carp	WB	Beryllium	Trace Metals	5	3	1.0	3.0	1.6	1.1
Carp	WB	Cadmium	Trace Metals	5	5	10	40	17	13
Carp	WB	Chromium	Trace Metals	5	5	340	640	480	120
Carp	WB	Copper	Trace Metals	5	5	1,300	2,800	1,700	610
Carp	WB	Lead	Trace Metals	5	5	14	49	30	13
Carp	WB	Mercury	Trace Metals	5	5	96	160	130	29
Carp	WB	Nickel	Trace Metals	5	3	1.0	310	100	130
Carp	WB	Silver	Trace Metals	5	5	10	30	20	7.1
Carp	WB	Thallium	Trace Metals	5	0	2.0	2.0	2.0	0.00
Carp	WB	Zinc	Trace Metals	5	5	75,000	100,000	86,000	13,000
Carp	WB	Aroclor 1242	PCB Aroclors	5	5	3.9	7.6	5.6	1.7
Carp	WB	Aroclor 1254	PCB Aroclors	5	5	59	110	75	21
Carp	WB	Aroclor 1260	PCB Aroclors	5	5	40	120	65	32
Carp	WB	33'44'-TeCB	PCB Congeners	5	5	0.052	0.099	0.074	0.018
Carp	WB	233'44'-PeCB	PCB Congeners	5	5	1.6	2.8	2.0	0.47
Carp	WB	2344'5-PeCB	PCB Congeners	5	5	0.13	0.28	0.18	0.058
Carp	WB	23'44'5-PeCB	PCB Congeners	5	5	6.4	11	7.8	1.8
Carp	WB	2'344'5-PeCB	PCB Congeners	5	5	0.00	0.27	0.22	0.027
Carp	WB	33'44'5-PeCB	PCB Congeners	5	4	0.014	0.024	0.015	0.0020
Carp	WB	233'44'5-HxCB	PCB Congeners	5	5	0.78	1.8	1.1	0.39
Carp	WB	23'44'55'-HxCB	PCB Congeners	5	5	0.37	0.87	0.54	0.19
Carp	WB	33'44'55'-HxCB	PCB Congeners	5	5	0.00	0.036	0.023	0.0077
Carp	WB	22'33'44'5-HpCB	PCB Congeners	5	5	1.4	4.0	2.3	1.00
Carp	WB	22'344'55'-HpCB	PCB Congeners	5	5	4.5	13	7.6	3.2
Carp	WB	233'44'55'-HpCB	PCB Congeners	5	5	0.058	0.18	0.11	0.045
Carp	WB	Aldrin	Pesticides	5	4	0.11	2.4	1.3	1.1
Carp	WB	alpha HCH	Pesticides	5	3	0.12	0.37	0.17	0.11
Carp	WB	alpha-Endosulfan (I)	Pesticides	5	2	0.0075	0.74	0.23	0.33
Carp	WB	beta HCH	Pesticides	5	2	0.13	0.40	0.15	0.066
Carp	WB	cis-Chlordane	Pesticides	5	5	3.7	5.7	4.7	0.86
Carp	WB	cis-Nonachlor	Pesticides	5	5	2.9	4.2	3.3	0.53
Carp	WB	o,p'-DDD	Pesticides	1	5	1.5	2.4	2.0	0.38
Carp	WB	o,p'-DDE	Pesticides	1	5	0.34	0.66	0.50	0.14
Carp	WB	o,p'-DDT	Pesticides	1	5	1.7	2.0	1.8	0.12
Carp	WB	p,p'-DDD	Pesticides	1	5	15	19	17	1.8
Carp	WB	p,p'-DDE	Pesticides	1	5	120	300	190	73
Carp	WB	p,p'-DDT	Pesticides	1	5	1.6	3.5	2.2	0.79
Carp	WB	Dieldrin	Pesticides	5	5	1.9	5.6	3.7	1.4
Carp	WB	Endrin	Pesticides	5	1	0.020	0.060	0.020	0.0080
Carp	WB	gamma HCH	Pesticides	5	5	0.82	1.4	1.1	0.27
Carp	WB	Heptachlor	Pesticides	5	0	0.14	0.25	0.19	0.041
Carp	WB	Heptachlor Epoxide	Pesticides	5	5	0.18	0.44	0.31	0.11
Carp	WB	Hexachlorobenzene	Pesticides	1	5	4.1	7.6	5.1	1.5
Carp	WB	Methoxychlor	Pesticides	1	1	0.020	0.64	0.16	0.27

Table D-1. Summary statistics for fish species

Species	Sample Type	Chemical	Chemical Group	Number of Samples	Detection Frequency	Minimum (ug/kg)	Maximum (ug/kg)	Average (ug/kg)	Standard Deviation
Carp	WB	Mirex	Pesticides	1	5	0.13	0.33	0.19	0.081
Carp	WB	Oxychlordane	Pesticides	1	4	1.3	4.3	2.1	1.3
Carp	WB	trans-Chlordane	Pesticides	1	5	1.5	2.4	2.1	0.36
Carp	WB	trans-Nonachlor	Pesticides	1	5	7.0	11	3.8	1.5
Carp	WB	Acenaphthene	PAHs	5	5	1.1	3.6	1.9	1.2
Carp	WB	Acenaphthylene	PAHs	5	4	0.87	1.1	0.89	0.22
Carp	WB	Anthracene	PAHs	5	3	0.18	0.83	0.40	0.26
Carp	WB	Benz[a]anthracene	PAHs	5	1	0.078	2.7	0.70	1.1
Carp	WB	Benzo[a]pyrene	PAHs	5	1	0.17	4.3	1.1	1.8
Carp	WB	Benzo[e]pyrene	PAHs	5	1	0.18	3.4	0.90	1.4
Carp	WB	Benzo[ghi]perylene	PAHs	5	2	0.087	4.9	1.1	2.1
Carp	WB	Benzo[b/j/k]fluoranthenes	PAHs	5	1	0.063	6.0	1.4	2.6
Carp	WB	Chrysene	PAHs	5	3	0.22	3.0	0.85	1.2
Carp	WB	Dibenz[ah]anthracene	PAHs	5	0	0.091	0.97	0.62	0.37
Carp	WB	Fluoranthene	PAHs	5	3	0.57	3.8	1.3	1.4
Carp	WB	Fluorene	PAHs	5	4	1.0	1.5	1.1	0.38
Carp	WB	Indeno[1,2,3-cd]pyrene	PAHs	5	2	0.059	3.4	0.83	1.4
Carp	WB	Naphthalene	PAHs	5	5	7.4	17	11	3.7
Carp	WB	Perylene	PAHs	5	1	0.22	1.9	0.62	0.73
Carp	WB	Phenanthrene	PAHs	5	5	1.7	3.4	2.2	0.71
Carp	WB	Pyrene	PAHs	5	5	0.68	5.6	1.8	2.1
Carp	WB-fillet	2,3,7,8-TCDD	Dioxin/Furans	1	1	0.00086	0.00086	0.00086	na
Carp	WB-fillet	1,2,3,7,8-PeCDD	Dioxin/Furans	1	1	0.0011	0.0011	0.0011	na
Carp	WB-fillet	1,2,3,4,7,8-HxCDD	Dioxin/Furans	1	1	0.00080	0.00080	0.00080	na
Carp	WB-fillet	1,2,3,6,7,8-HxCDD	Dioxin/Furans	1	1	0.0029	0.0029	0.0029	na
Carp	WB-fillet	1,2,3,7,8,9-HxCDD	Dioxin/Furans	1	1	0.00038	0.00038	0.00038	na
Carp	WB-fillet	1,2,3,4,6,7,8-HpCDD	Dioxin/Furans	1	1	0.0052	0.0052	0.0052	na
Carp	WB-fillet	OCDD	Dioxin/Furans	1	1	0.0055	0.0055	0.0055	na
Carp	WB-fillet	2,3,7,8-TCDF	Dioxin/Furans	1	1	0.00095	0.00095	0.00095	na
Carp	WB-fillet	1,2,3,7,8-PeCDF	Dioxin/Furans	1	1	0.00028	0.00028	0.00028	na
Carp	WB-fillet	2,3,4,7,8-PeCDF	Dioxin/Furans	1	1	0.00070	0.00070	0.00070	na
Carp	WB-fillet	1,2,3,4,7,8-HxCDF	Dioxin/Furans	1	1	0.00042	0.00042	0.00042	na
Carp	WB-fillet	1,2,3,6,7,8-HxCDF	Dioxin/Furans	1	1	0.00030	0.00030	0.00030	na
Carp	WB-fillet	1,2,3,7,8,9-HxCDF	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Carp	WB-fillet	2,3,4,6,7,8-HxCDF	Dioxin/Furans	1	1	0.00026	0.00026	0.00026	na
Carp	WB-fillet	1,2,3,4,6,7,8-HpCDF	Dioxin/Furans	1	1	0.00065	0.00065	0.00065	na
Carp	WB-fillet	1,2,3,4,7,8,9-HpCDF	Dioxin/Furans	1	0	0.00015	0.00015	0.00015	na
Carp	WB-fillet	OCDF	Dioxin/Furans	1	0	0.00030	0.00030	0.00030	na
Carp	WB-fillet	Antimony	Trace Metals	1	0	1.0	1.0	1.0	na
Carp	WB-fillet	Arsenic	Trace Metals	1	1	170	170	170	na
Carp	WB-fillet	Total Inorganic Arsenic	Trace Metals	1	1	6.0	6.0	6.0	na
Carp	WB-fillet	Beryllium	Trace Metals	1	0	1.0	1.0	1.0	na
Carp	WB-fillet	Cadmium	Trace Metals	1	1	20	20	20	na
Carp	WB-fillet	Chromium	Trace Metals	1	1	510	510	510	na
Carp	WB-fillet	Copper	Trace Metals	1	1	1,800	1,800	1,800	na
Carp	WB-fillet	Lead	Trace Metals	1	1	33	33	33	na
Carp	WB-fillet	Mercury	Trace Metals	1	1	75	75	75	na
Carp	WB-fillet	Nickel	Trace Metals	1	0	10	10	10	na
Carp	WB-fillet	Silver	Trace Metals	1	1	30	30	30	na
Carp	WB-fillet	Thallium	Trace Metals	1	0	2.0	2.0	2.0	na
Carp	WB-fillet	Zinc	Trace Metals	1	1	110,000	110,000	110,000	na
Carp	WB-fillet	Aroclor 1242	PCB Aroclors	2	1	6.6	6.6	6.6	na
Carp	WB-fillet	Aroclor 1254	PCB Aroclors	2	1	87	87	87	na
Carp	WB-fillet	Aroclor 1260	PCB Aroclors	2	1	67	67	67	na
Carp	WB-fillet	33'44'-TeCB	PCB Congeners	1	1	0.084	0.084	0.084	na
Carp	WB-fillet	233'44'-PeCB	PCB Congeners	1	1	2.3	2.3	2.3	na
Carp	WB-fillet	2344'5-PeCB	PCB Congeners	1	1	0.22	0.22	0.22	na
Carp	WB-fillet	23'44'5-PeCB	PCB Congeners	1	1	9.2	9.2	9.2	na
Carp	WB-fillet	2'344'5-PeCB	PCB Congeners	1	1	0.27	0.27	0.27	na
Carp	WB-fillet	33'44'5-PeCB	PCB Congeners	1	1	0.021	0.021	0.021	na
Carp	WB-fillet	233'44'5-HxCB	PCB Congeners	1	1	1.4	1.4	1.4	na
Carp	WB-fillet	23'44'55'-HxCB	PCB Congeners	1	1	0.68	0.68	0.68	na
Carp	WB-fillet	33'44'55'-HxCB	PCB Congeners	1	1	0.020	0.020	0.020	na
Carp	WB-fillet	22'33'44'5-HpCB	PCB Congeners	1	1	2.5	2.5	2.5	na
Carp	WB-fillet	22'344'55'-HpCB	PCB Congeners	1	1	8.6	8.6	8.6	na
Carp	WB-fillet	233'44'55'-HpCB	PCB Congeners	1	1	0.12	0.12	0.12	na
Carp	WB-Fillet	Aldrin	Pesticides	5	1	3.8	3.8	3.8	na
Carp	WB-Fillet	alpha HCH	Pesticides	5	1	0.53	0.53	0.53	na
Carp	WB-Fillet	alpha-Endosulfan (I)	Pesticides	5	1	0.67	0.67	0.67	na
Carp	WB-Fillet	beta HCH	Pesticides	5	1	0.30	0.30	0.30	na
Carp	WB-Fillet	cis-Chlordane	Pesticides	5	1	4.6	4.6	4.6	na
Carp	WB-Fillet	cis-Nonachlor	Pesticides	5	1	4.0	4.0	4.0	na
Carp	WB-Fillet	o,p'-DDD	Pesticides	5	1	1.9	1.9	1.9	na
Carp	WB-Fillet	o,p'-DDE	Pesticides	5	1	0.52	0.52	0.52	na
Carp	WB-Fillet	o,p'-DDT	Pesticides	5	1	2.2	2.2	2.2	na
Carp	WB-Fillet	p,p'-DDD	Pesticides	5	1	19	19	19	na
Carp	WB-Fillet	p,p'-DDE	Pesticides	5	1	380	380	380	na
Carp	WB-Fillet	p,p'-DDT	Pesticides	5	1	2.5	2.5	2.5	na

Table D-1. Summary statistics for fish species

Species	Sample Type	Chemical	Chemical Group	Number of Samples	Detection Frequency	Minimum (ug/kg)	Maximum (ug/kg)	Average (ug/kg)	Standard Deviation
Carp	WB-Fillet	Dieldrin	Pesticides	5	1	4.3	4.3	4.3	na
Carp	WB-Fillet	Endrin	Pesticides	5	0	0.040	0.040	0.040	na
Carp	WB-Fillet	gamma HCH	Pesticides	5	1	1.7	1.7	1.7	na
Carp	WB-Fillet	Heptachlor	Pesticides	5	0	0.16	0.16	0.16	na
Carp	WB-Fillet	Heptachlor Epoxide	Pesticides	5	1	0.37	0.37	0.37	na
Carp	WB-Fillet	Hexachlorobenzene	Pesticides	5	1	5.4	5.4	5.4	na
Carp	WB-Fillet	Methoxychlor	Pesticides	5	0	0.095	0.095	0.095	na
Carp	WB-Fillet	Mirex	Pesticides	5	1	0.23	0.23	0.23	na
Carp	WB-Fillet	Oxychlordane	Pesticides	5	1	2.7	2.7	2.7	na
Carp	WB-Fillet	trans-Chlordane	Pesticides	5	1	1.9	1.9	1.9	na
Carp	WB-Fillet	trans-Nonachlor	Pesticides	5	1	10	10	10	na
Carp	WB-Fillet	Acenaphthene	PAHs	1	1	1.2	1.2	1.2	na
Carp	WB-Fillet	Acenaphthylene	PAHs	1	0	0.70	0.70	0.70	na
Carp	WB-Fillet	Anthracene	PAHs	1	1	0.39	0.39	0.39	na
Carp	WB-Fillet	Benz[a]anthracene	PAHs	1	0	0.81	0.81	0.81	na
Carp	WB-Fillet	Benzo[a]pyrene	PAHs	1	0	0.51	0.51	0.51	na
Carp	WB-Fillet	Benzo[e]pyrene	PAHs	1	0	0.49	0.49	0.49	na
Carp	WB-Fillet	Benzo[ghi]perylene	PAHs	1	0	0.40	0.40	0.40	na
Carp	WB-Fillet	Benzo[b/j/k]fluoranthenes	PAHs	1	0	0.47	0.47	0.47	na
Carp	WB-Fillet	Chrysene	PAHs	1	0	0.84	0.84	0.84	na
Carp	WB-Fillet	Dibenz[ah]anthracene	PAHs	1	0	0.43	0.43	0.43	na
Carp	WB-Fillet	Fluoranthene	PAHs	1	0	0.65	0.65	0.65	na
Carp	WB-Fillet	Fluorene	PAHs	1	0	0.72	0.72	0.72	na
Carp	WB-Fillet	Indeno[1,2,3-cd]pyrene	PAHs	1	0	0.45	0.45	0.45	na
Carp	WB-Fillet	Naphthalene	PAHs	1	1	12	12	12	na
Carp	WB-Fillet	Perylene	PAHs	1	0	0.54	0.54	0.54	na
Carp	WB-Fillet	Phenanthrene	PAHs	1	1	1.7	1.7	1.7	na
Carp	WB-Fillet	Pyrene	PAHs	1	1	0.68	0.68	0.68	na
Pikeminnow	Fillet	2,3,7,8-TCDD	Dioxin/Furans	1	1	0.00013	0.00013	0.00013	na
Pikeminnow	Fillet	1,2,3,7,8-PeCDD	Dioxin/Furans	1	1	0.00018	0.00018	0.00018	na
Pikeminnow	Fillet	1,2,3,4,7,8-HxCDD	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Pikeminnow	Fillet	1,2,3,6,7,8-HxCDD	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Pikeminnow	Fillet	1,2,3,7,8,9-HxCDD	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Pikeminnow	Fillet	1,2,3,4,6,7,8-HpCDD	Dioxin/Furans	1	1	0.00051	0.00051	0.00051	na
Pikeminnow	Fillet	OCDD	Dioxin/Furans	1	1	0.00089	0.00089	0.00089	na
Pikeminnow	Fillet	2,3,7,8-TCDF	Dioxin/Furans	1	1	0.00044	0.00044	0.00044	na
Pikeminnow	Fillet	1,2,3,7,8-PeCDF	Dioxin/Furans	1	0	0.000080	0.000080	0.000080	na
Pikeminnow	Fillet	2,3,4,7,8-PeCDF	Dioxin/Furans	1	1	0.00013	0.00013	0.00013	na
Pikeminnow	Fillet	1,2,3,4,7,8-HxCDF	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Pikeminnow	Fillet	1,2,3,6,7,8-HxCDF	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Pikeminnow	Fillet	1,2,3,7,8,9-HxCDF	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Pikeminnow	Fillet	2,3,4,6,7,8-HxCDF	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Pikeminnow	Fillet	1,2,3,4,6,7,8-HpCDF	Dioxin/Furans	1	0	0.00015	0.00015	0.00015	na
Pikeminnow	Fillet	1,2,3,4,7,8,9-HpCDF	Dioxin/Furans	1	0	0.00015	0.00015	0.00015	na
Pikeminnow	Fillet	OCDF	Dioxin/Furans	1	0	0.00030	0.00030	0.00030	na
Pikeminnow	Fillet	Antimony	Trace Metals	1	0	1.0	1.0	1.0	na
Pikeminnow	Fillet	Arsenic	Trace Metals	1	0	50	50	50	na
Pikeminnow	Fillet	Total Inorganic Arsenic	Trace Metals	1	0	3.0	3.0	3.0	na
Pikeminnow	Fillet	Beryllium	Trace Metals	1	1	2.0	2.0	2.0	na
Pikeminnow	Fillet	Cadmium	Trace Metals	1	0	10	10	10	na
Pikeminnow	Fillet	Chromium	Trace Metals	1	1	180	180	180	na
Pikeminnow	Fillet	Copper	Trace Metals	1	1	490	490	490	na
Pikeminnow	Fillet	Lead	Trace Metals	1	0	5.0	5.0	5.0	na
Pikeminnow	Fillet	Mercury	Trace Metals	1	1	720	720	720	na
Pikeminnow	Fillet	Nickel	Trace Metals	1	1	40	40	40	na
Pikeminnow	Fillet	Silver	Trace Metals	1	0	10	10	10	na
Pikeminnow	Fillet	Thallium	Trace Metals	1	0	2.0	2.0	2.0	na
Pikeminnow	Fillet	Zinc	Trace Metals	1	1	6,900	6,900	6,900	na
Pikeminnow	Fillet	Aroclor 1242	PCB Aroclors	1	0	3.4	3.4	3.4	na
Pikeminnow	Fillet	Aroclor 1254	PCB Aroclors	1	1	16	16	16	na
Pikeminnow	Fillet	Aroclor 1260	PCB Aroclors	1	1	17	17	17	na
Pikeminnow	Fillet	33'44'-TeCB	PCB Congeners	1	1	0.035	0.035	0.035	na
Pikeminnow	Fillet	233'44'-PeCB	PCB Congeners	1	1	0.75	0.75	0.75	na
Pikeminnow	Fillet	2344'5-PeCB	PCB Congeners	1	1	0.071	0.071	0.071	na
Pikeminnow	Fillet	23'44'5-PeCB	PCB Congeners	1	1	2.5	2.5	2.5	na
Pikeminnow	Fillet	2'344'5-PeCB	PCB Congeners	1	1	0.061	0.061	0.061	na
Pikeminnow	Fillet	33'44'5-PeCB	PCB Congeners	1	1	0.0067	0.0067	0.0067	na
Pikeminnow	Fillet	233'44'5-HxCB	PCB Congeners	1	1	0.40	0.40	0.40	na
Pikeminnow	Fillet	23'44'55'-HxCB	PCB Congeners	1	1	0.17	0.17	0.17	na
Pikeminnow	Fillet	33'44'55'-HxCB	PCB Congeners	1	1	0.0061	0.0061	0.0061	na
Pikeminnow	Fillet	22'33'44'5-HpCB	PCB Congeners	1	1	0.61	0.61	0.61	na
Pikeminnow	Fillet	22'344'55'-HpCB	PCB Congeners	1	1	1.8	1.8	1.8	na
Pikeminnow	Fillet	233'44'55'-HpCB	PCB Congeners	1	1	0.030	0.030	0.030	na
Pikeminnow	Fillet	Aldrin	Pesticides	1	1	6.5	6.5	6.5	na
Pikeminnow	Fillet	alpha HCH	Pesticides	1	0	0.54	0.54	0.54	na
Pikeminnow	Fillet	alpha-Endosulfan (I)	Pesticides	1	0	0.020	0.020	0.020	na
Pikeminnow	Fillet	beta HCH	Pesticides	1	0	0.69	0.69	0.69	na
Pikeminnow	Fillet	cis-Chlordane	Pesticides	1	1	0.45	0.45	0.45	na

Table D-1. Summary statistics for fish species

Species	Sample Type	Chemical	Chemical Group	Number of Samples	Detection Frequency	Minimum (ug/kg)	Maximum (ug/kg)	Average (ug/kg)	Standard Deviation
Pikeminnow	Fillet	cis-Nonachlor	Pesticides	1	1	0.45	0.45	0.45	na
Pikeminnow	Fillet	o,p'-DDD	Pesticides	1	1	0.24	0.24	0.24	na
Pikeminnow	Fillet	o,p'-DDE	Pesticides	1	1	0.16	0.16	0.16	na
Pikeminnow	Fillet	o,p'-DDT	Pesticides	1	1	0.32	0.32	0.32	na
Pikeminnow	Fillet	p,p'-DDD	Pesticides	1	1	2.5	2.5	2.5	na
Pikeminnow	Fillet	p,p'-DDE	Pesticides	1	1	22	22	22	na
Pikeminnow	Fillet	p,p'-DDT	Pesticides	1	1	0.28	0.28	0.28	na
Pikeminnow	Fillet	Dieldrin	Pesticides	1	1	0.52	0.52	0.52	na
Pikeminnow	Fillet	Endrin	Pesticides	1	0	0.030	0.030	0.030	na
Pikeminnow	Fillet	gamma HCH	Pesticides	1	1	1.1	1.1	1.1	na
Pikeminnow	Fillet	Heptachlor	Pesticides	1	0	0.24	0.24	0.24	na
Pikeminnow	Fillet	Heptachlor Epoxide	Pesticides	1	0	0.010	0.010	0.010	na
Pikeminnow	Fillet	Hexachlorobenzene	Pesticides	1	1	1.0	1.0	1.0	na
Pikeminnow	Fillet	Methoxychlor	Pesticides	1	0	0.060	0.060	0.060	na
Pikeminnow	Fillet	Mirex	Pesticides	1	1	0.090	0.090	0.090	na
Pikeminnow	Fillet	Oxychlordane	Pesticides	1	0	2.9	2.9	2.9	na
Pikeminnow	Fillet	trans-Chlordane	Pesticides	1	1	0.22	0.22	0.22	na
Pikeminnow	Fillet	trans-Nonachlor	Pesticides	1	1	1.5	1.5	1.5	na
Pikeminnow	Fillet	Acenaphthene	PAHs	1	0	1.0	1.0	1.0	na
Pikeminnow	Fillet	Acenaphthylene	PAHs	1	0	0.98	0.98	0.98	na
Pikeminnow	Fillet	Anthracene	PAHs	1	0	0.68	0.68	0.68	na
Pikeminnow	Fillet	Benz[a]anthracene	PAHs	1	0	0.31	0.31	0.31	na
Pikeminnow	Fillet	Benzo[a]pyrene	PAHs	1	0	0.60	0.60	0.60	na
Pikeminnow	Fillet	Benzo[e]pyrene	PAHs	1	0	0.58	0.58	0.58	na
Pikeminnow	Fillet	Benzo[ghi]perylene	PAHs	1	0	0.86	0.86	0.86	na
Pikeminnow	Fillet	Benzo[b/j/k]fluoranthenes	PAHs	1	0	0.56	0.56	0.56	na
Pikeminnow	Fillet	Chrysene	PAHs	1	0	0.32	0.32	0.32	na
Pikeminnow	Fillet	Dibenz[ah]anthracene	PAHs	1	0	1.1	1.1	1.1	na
Pikeminnow	Fillet	Fluoranthene	PAHs	1	1	0.46	0.46	0.46	na
Pikeminnow	Fillet	Fluorene	PAHs	1	0	1.0	1.0	1.0	na
Pikeminnow	Fillet	Indeno[1,2,3-cd]pyrene	PAHs	1	0	0.97	0.97	0.97	na
Pikeminnow	Fillet	Naphthalene	PAHs	1	1	9.9	9.9	9.9	na
Pikeminnow	Fillet	Perylene	PAHs	1	0	0.61	0.61	0.61	na
Pikeminnow	Fillet	Phenanthrene	PAHs	1	1	1.6	1.6	1.6	na
Pikeminnow	Fillet	Pyrene	PAHs	1	1	1.1	1.1	1.1	na
Pikeminnow	WB	2,3,7,8-TCDD	Dioxin/Furans	3	3	0.00019	0.00047	0.00037	0.00016
Pikeminnow	WB	1,2,3,7,8-PeCDD	Dioxin/Furans	3	3	0.00025	0.00075	0.00056	0.00027
Pikeminnow	WB	1,2,3,4,7,8-HxCDD	Dioxin/Furans	3	3	0.00012	0.00037	0.00027	0.00013
Pikeminnow	WB	1,2,3,6,7,8-HxCDD	Dioxin/Furans	3	3	0.00046	0.0013	0.00099	0.00046
Pikeminnow	WB	1,2,3,7,8,9-HxCDD	Dioxin/Furans	3	2	0.000080	0.00023	0.00012	0.000096
Pikeminnow	WB	1,2,3,4,6,7,8-HpCDD	Dioxin/Furans	3	3	0.00091	0.0022	0.0017	0.00069
Pikeminnow	WB	OCDD	Dioxin/Furans	3	3	0.0016	0.0029	0.0023	0.00068
Pikeminnow	WB	2,3,7,8-TCDF	Dioxin/Furans	3	3	0.00068	0.0018	0.0013	0.00060
Pikeminnow	WB	1,2,3,7,8-PeCDF	Dioxin/Furans	3	1	0.000090	0.00019	0.000093	0.000083
Pikeminnow	WB	2,3,4,7,8-PeCDF	Dioxin/Furans	3	3	0.00017	0.00053	0.00041	0.00020
Pikeminnow	WB	1,2,3,4,7,8-HxCDF	Dioxin/Furans	3	1	0.00010	0.00020	0.000100	0.000086
Pikeminnow	WB	1,2,3,6,7,8-HxCDF	Dioxin/Furans	3	2	0.00010	0.00016	0.00012	0.000059
Pikeminnow	WB	1,2,3,7,8,9-HxCDF	Dioxin/Furans	3	0	0.00010	0.00010	0.00010	0.00
Pikeminnow	WB	2,3,4,6,7,8-HxCDF	Dioxin/Furans	3	2	0.00010	0.00019	0.00012	0.000070
Pikeminnow	WB	1,2,3,4,6,7,8-HpCDF	Dioxin/Furans	3	1	0.00015	0.00028	0.00014	0.00012
Pikeminnow	WB	1,2,3,4,7,8,9-HpCDF	Dioxin/Furans	3	0	0.00015	0.00015	0.00015	0.00
Pikeminnow	WB	OCDF	Dioxin/Furans	3	0	0.00030	0.00030	0.00030	0.00
Pikeminnow	WB	Antimony	Trace Metals	3	0	1.0	1.0	1.0	0.00
Pikeminnow	WB	Arsenic	Trace Metals	3	0	50	50	50	0.00
Pikeminnow	WB	Total Inorganic Arsenic	Trace Metals	3	0	3.0	3.0	3.0	0.00
Pikeminnow	WB	Beryllium	Trace Metals	3	1	1.0	1.1	0.70	0.35
Pikeminnow	WB	Cadmium	Trace Metals	3	1	10	20	10	8.7
Pikeminnow	WB	Chromium	Trace Metals	3	3	170	180	180	3.4
Pikeminnow	WB	Copper	Trace Metals	3	3	560	1,100	800	270
Pikeminnow	WB	Lead	Trace Metals	3	2	5.0	7.0	5.2	2.4
Pikeminnow	WB	Mercury	Trace Metals	3	3	57	490	340	250
Pikeminnow	WB	Nickel	Trace Metals	3	1	10	19	9.7	8.1
Pikeminnow	WB	Silver	Trace Metals	3	0	10	10	10	0.00000016
Pikeminnow	WB	Thallium	Trace Metals	3	0	2.0	2.0	2.0	0.00
Pikeminnow	WB	Zinc	Trace Metals	3	3	10,000	18,000	14,000	4,100
Pikeminnow	WB	Aroclor 1242	PCB Aroclors	2	3	2.4	5.4	3.6	1.2
Pikeminnow	WB	Aroclor 1254	PCB Aroclors	2	3	28	66	51	20
Pikeminnow	WB	Aroclor 1260	PCB Aroclors	2	3	17	62	47	26
Pikeminnow	WB	33'44'-TeCB	PCB Congeners	3	3	0.062	0.13	0.097	0.033
Pikeminnow	WB	233'44'-PeCB	PCB Congeners	3	3	1.2	2.6	2.1	0.75
Pikeminnow	WB	2344'5-PeCB	PCB Congeners	3	3	0.074	0.25	0.18	0.094
Pikeminnow	WB	23'44'5-PeCB	PCB Congeners	3	3	4.1	9.7	7.5	3.0
Pikeminnow	WB	2'344'5-PeCB	PCB Congeners	3	3	0.086	0.22	0.17	0.073
Pikeminnow	WB	33'44'5-PeCB	PCB Congeners	3	3	0.0090	0.025	0.018	0.0085
Pikeminnow	WB	233'44'5-HxCB	PCB Congeners	3	3	0.47	1.6	1.1	0.59
Pikeminnow	WB	23'44'55'-HxCB	PCB Congeners	3	3	0.18	0.77	0.50	0.30
Pikeminnow	WB	33'44'55'-HxCB	PCB Congeners	3	3	0.00	0.027	0.020	0.0095
Pikeminnow	WB	22'33'44'5-HpCB	PCB Congeners	3	3	0.65	2.0	1.5	0.72

Table D-1. Summary statistics for fish species

Species	Sample Type	Chemical	Chemical Group	Number of Samples	Detection Frequency	Minimum (ug/kg)	Maximum (ug/kg)	Average (ug/kg)	Standard Deviation
Pikeminnow	WB	22'344'55'-HpCB	PCB Congeners	3	3	2.1	7.4	5.4	2.9
Pikeminnow	WB	233'44'55'-HpCB	PCB Congeners	3	3	0.032	0.11	0.080	0.042
Pikeminnow	WB	Aldrin	Pesticides	3	1	0.030	4.1	1.4	2.3
Pikeminnow	WB	alpha HCH	Pesticides	3	1	0.040	0.54	0.20	0.21
Pikeminnow	WB	alpha-Endosulfan (I)	Pesticides	3	0	0.010	0.040	0.021	0.016
Pikeminnow	WB	beta HCH	Pesticides	3	1	0.060	0.44	0.16	0.11
Pikeminnow	WB	cis-Chlordane	Pesticides	3	3	0.89	2.1	1.6	0.61
Pikeminnow	WB	cis-Nonachlor	Pesticides	3	3	0.87	2.2	1.6	0.69
Pikeminnow	WB	o,p'-DDD	Pesticides	1	3	0.29	0.81	0.64	0.30
Pikeminnow	WB	o,p'-DDE	Pesticides	1	3	0.22	0.63	0.45	0.21
Pikeminnow	WB	o,p'-DDT	Pesticides	1	3	0.85	2.1	1.4	0.64
Pikeminnow	WB	p,p'-DDD	Pesticides	1	3	2.8	9.0	6.9	3.5
Pikeminnow	WB	p,p'-DDE	Pesticides	1	3	45	120	86	38
Pikeminnow	WB	p,p'-DDT	Pesticides	1	3	0.12	0.43	0.30	0.16
Pikeminnow	WB	Dieldrin	Pesticides	3	3	0.86	2.1	1.6	0.67
Pikeminnow	WB	Endrin	Pesticides	3	0	0.020	0.070	0.040	0.026
Pikeminnow	WB	gamma HCH	Pesticides	1	3	0.64	1.1	0.93	0.25
Pikeminnow	WB	Heptachlor	Pesticides	1	0	0.15	0.27	0.20	0.064
Pikeminnow	WB	Heptachlor Epoxide	Pesticides	1	2	0.030	0.17	0.11	0.082
Pikeminnow	WB	Hexachlorobenzene	Pesticides	1	3	2.3	3.2	2.9	0.52
Pikeminnow	WB	Methoxychlor	Pesticides	1	1	0.030	0.19	0.088	0.080
Pikeminnow	WB	Mirex	Pesticides	1	3	0.070	0.25	0.18	0.094
Pikeminnow	WB	Oxychlordane	Pesticides	1	3	0.89	3.6	1.9	1.0
Pikeminnow	WB	trans-Chlordane	Pesticides	1	3	0.43	0.91	0.70	0.24
Pikeminnow	WB	trans-Nonachlor	Pesticides	1	3	3.4	8.0	6.0	2.4
Pikeminnow	WB	Acenaphthene	PAHs	4	2	1.4	2.3	1.7	0.57
Pikeminnow	WB	Acenaphthylene	PAHs	4	3	0.46	0.88	0.56	0.12
Pikeminnow	WB	Anthracene	PAHs	4	1	0.16	0.68	0.24	0.093
Pikeminnow	WB	Benz[a]anthracene	PAHs	4	0	0.033	0.20	0.13	0.087
Pikeminnow	WB	Benzo[a]pyrene	PAHs	4	0	0.12	1.1	0.69	0.51
Pikeminnow	WB	Benzo[e]pyrene	PAHs	4	0	0.10	3.6	1.6	1.8
Pikeminnow	WB	Benzo[ghi]perylene	PAHs	4	2	0.052	0.75	0.22	0.31
Pikeminnow	WB	Benzo[b/j/k]fluoranthenes	PAHs	4	0	0.099	1.0	0.66	0.49
Pikeminnow	WB	Chrysene	PAHs	4	0	0.065	0.19	0.14	0.069
Pikeminnow	WB	Dibenz[ah]anthracene	PAHs	4	1	0.064	0.92	0.26	0.38
Pikeminnow	WB	Fluoranthene	PAHs	4	3	0.27	0.66	0.53	0.22
Pikeminnow	WB	Fluorene	PAHs	4	3	1.3	1.8	1.5	0.28
Pikeminnow	WB	Indeno[1,2,3-cd]pyrene	PAHs	4	1	0.043	0.72	0.19	0.29
Pikeminnow	WB	Naphthalene	PAHs	4	3	3.9	7.0	5.0	1.8
Pikeminnow	WB	Perylene	PAHs	4	0	0.20	1.4	0.80	0.62
Pikeminnow	WB	Phenanthrene	PAHs	4	3	1.3	2.0	1.7	0.37
Pikeminnow	WB	Pyrene	PAHs	4	2	0.16	0.69	0.49	0.29
Pikeminnow	WB-fillet	2,3,7,8-TCDD	Dioxin/Furans	1	1	0.00070	0.00070	0.00070	na
Pikeminnow	WB-fillet	1,2,3,7,8-PeCDD	Dioxin/Furans	1	1	0.0011	0.0011	0.0011	na
Pikeminnow	WB-fillet	1,2,3,4,7,8-HxCDD	Dioxin/Furans	1	1	0.00050	0.00050	0.00050	na
Pikeminnow	WB-fillet	1,2,3,6,7,8-HxCDD	Dioxin/Furans	1	1	0.0021	0.0021	0.0021	na
Pikeminnow	WB-fillet	1,2,3,7,8,9-HxCDD	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Pikeminnow	WB-fillet	1,2,3,4,6,7,8-HpCDD	Dioxin/Furans	1	1	0.0033	0.0033	0.0033	na
Pikeminnow	WB-fillet	OCDD	Dioxin/Furans	1	1	0.0037	0.0037	0.0037	na
Pikeminnow	WB-fillet	2,3,7,8-TCDF	Dioxin/Furans	1	1	0.0028	0.0028	0.0028	na
Pikeminnow	WB-fillet	1,2,3,7,8-PeCDF	Dioxin/Furans	1	1	0.00029	0.00029	0.00029	na
Pikeminnow	WB-fillet	2,3,4,7,8-PeCDF	Dioxin/Furans	1	1	0.00078	0.00078	0.00078	na
Pikeminnow	WB-fillet	1,2,3,4,7,8-HxCDF	Dioxin/Furans	1	1	0.00030	0.00030	0.00030	na
Pikeminnow	WB-fillet	1,2,3,6,7,8-HxCDF	Dioxin/Furans	1	1	0.00020	0.00020	0.00020	na
Pikeminnow	WB-fillet	1,2,3,7,8,9-HxCDF	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Pikeminnow	WB-fillet	2,3,4,6,7,8-HxCDF	Dioxin/Furans	1	1	0.00018	0.00018	0.00018	na
Pikeminnow	WB-fillet	1,2,3,4,6,7,8-HpCDF	Dioxin/Furans	1	0	0.00015	0.00015	0.00015	na
Pikeminnow	WB-fillet	1,2,3,4,7,8,9-HpCDF	Dioxin/Furans	1	0	0.00015	0.00015	0.00015	na
Pikeminnow	WB-fillet	OCDF	Dioxin/Furans	1	0	0.00030	0.00030	0.00030	na
Pikeminnow	WB-fillet	Antimony	Trace Metals	1	0	1.0	1.0	1.0	na
Pikeminnow	WB-fillet	Arsenic	Trace Metals	1	0	50	50	50	na
Pikeminnow	WB-fillet	Total Inorganic Arsenic	Trace Metals	1	0	3.0	3.0	3.0	na
Pikeminnow	WB-fillet	Beryllium	Trace Metals	1	0	1.0	1.0	1.0	na
Pikeminnow	WB-fillet	Cadmium	Trace Metals	1	0	10	10	10	na
Pikeminnow	WB-fillet	Chromium	Trace Metals	1	1	170	170	170	na
Pikeminnow	WB-fillet	Copper	Trace Metals	1	1	610	610	610	na
Pikeminnow	WB-fillet	Lead	Trace Metals	1	0	5.0	5.0	5.0	na
Pikeminnow	WB-fillet	Mercury	Trace Metals	1	1	340	340	340	na
Pikeminnow	WB-fillet	Nickel	Trace Metals	1	0	10	10	10	na
Pikeminnow	WB-fillet	Silver	Trace Metals	1	0	10	10	10	na
Pikeminnow	WB-fillet	Thallium	Trace Metals	1	0	2.0	2.0	2.0	na
Pikeminnow	WB-fillet	Zinc	Trace Metals	1	1	13,000	13,000	13,000	na
Pikeminnow	WB-fillet	Aroclor 1242	PCB Aroclors	1	1	6.8	6.8	6.8	na
Pikeminnow	WB-fillet	Aroclor 1254	PCB Aroclors	1	1	100	100	100	na
Pikeminnow	WB-fillet	Aroclor 1260	PCB Aroclors	1	1	92	92	92	na
Pikeminnow	WB-fillet	33'44'-TeCB	PCB Congeners	1	1	0.19	0.19	0.19	na
Pikeminnow	WB-fillet	233'44'-PeCB	PCB Congeners	1	1	3.8	3.8	3.8	na
Pikeminnow	WB-fillet	2344'5-PeCB	PCB Congeners	1	1	0.37	0.37	0.37	na

Table D-1. Summary statistics for fish species

Species	Sample Type	Chemical	Chemical Group	Number of Samples	Detection Frequency	Minimum (ug/kg)	Maximum (ug/kg)	Average (ug/kg)	Standard Deviation
Pikeminnow	WB-fillet	23'44'5-PeCB	PCB Congeners	1	1	13	13	13	na
Pikeminnow	WB-fillet	2'344'5-PeCB	PCB Congeners	1	1	0.32	0.32	0.32	na
Pikeminnow	WB-fillet	33'44'5-PeCB	PCB Congeners	1	1	0.038	0.038	0.038	na
Pikeminnow	WB-fillet	233'44'5-HxCB	PCB Congeners	1	1	2.0	2.0	2.0	na
Pikeminnow	WB-fillet	23'44'55'-HxCB	PCB Congeners	1	1	0.82	0.82	0.82	na
Pikeminnow	WB-fillet	33'44'55'-HxCB	PCB Congeners	1	1	0.035	0.035	0.035	na
Pikeminnow	WB-fillet	22'33'44'5-HpCB	PCB Congeners	1	1	2.9	2.9	2.9	na
Pikeminnow	WB-fillet	22'344'55'-HpCB	PCB Congeners	1	1	9.9	9.9	9.9	na
Pikeminnow	WB-fillet	233'44'55'-HpCB	PCB Congeners	1	1	0.16	0.16	0.16	na
Pikeminnow	WB-Fillet	Aldrin	Pesticides	3	1	2.4	2.4	2.4	na
Pikeminnow	WB-Fillet	alpha HCH	Pesticides	3	1	0.54	0.54	0.54	na
Pikeminnow	WB-Fillet	alpha-Endosulfan (I)	Pesticides	3	0	0.010	0.010	0.010	na
Pikeminnow	WB-Fillet	beta HCH	Pesticides	3	1	0.13	0.13	0.13	na
Pikeminnow	WB-Fillet	cis-Chlordane	Pesticides	3	1	2.5	2.5	2.5	na
Pikeminnow	WB-Fillet	cis-Nonachlor	Pesticides	1	1	2.8	2.8	2.8	na
Pikeminnow	WB-Fillet	o,p'-DDD	Pesticides	1	1	1.2	1.2	1.2	na
Pikeminnow	WB-Fillet	o,p'-DDE	Pesticides	1	1	0.72	0.72	0.72	na
Pikeminnow	WB-Fillet	o,p'-DDT	Pesticides	1	1	1.9	1.9	1.9	na
Pikeminnow	WB-Fillet	p,p'-DDD	Pesticides	1	1	13	13	13	na
Pikeminnow	WB-Fillet	p,p'-DDE	Pesticides	1	1	140	140	140	na
Pikeminnow	WB-Fillet	p,p'-DDT	Pesticides	1	1	0.53	0.53	0.53	na
Pikeminnow	WB-Fillet	Dieldrin	Pesticides	1	1	3.2	3.2	3.2	na
Pikeminnow	WB-Fillet	Endrin	Pesticides	1	0	0.030	0.030	0.030	na
Pikeminnow	WB-Fillet	gamma HCH	Pesticides	1	1	1.0	1.0	1.0	na
Pikeminnow	WB-Fillet	Heptachlor	Pesticides	1	0	0.090	0.090	0.090	na
Pikeminnow	WB-Fillet	Heptachlor Epoxide	Pesticides	1	1	0.27	0.27	0.27	na
Pikeminnow	WB-Fillet	Hexachlorobenzene	Pesticides	1	1	4.7	4.7	4.7	na
Pikeminnow	WB-Fillet	Methoxychlor	Pesticides	1	1	0.27	0.27	0.27	na
Pikeminnow	WB-Fillet	Mirex	Pesticides	1	1	0.29	0.29	0.29	na
Pikeminnow	WB-Fillet	Oxychlordane	Pesticides	1	1	4.0	4.0	4.0	na
Pikeminnow	WB-Fillet	trans-Chlordane	Pesticides	1	1	1.1	1.1	1.1	na
Pikeminnow	WB-Fillet	trans-Nonachlor	Pesticides	1	1	10	10	10	na
Pikeminnow	WB-Fillet	Acenaphthene	PAHs	1	1	1.6	1.6	1.6	na
Pikeminnow	WB-Fillet	Acenaphthylene	PAHs	1	1	0.82	0.82	0.82	na
Pikeminnow	WB-Fillet	Anthracene	PAHs	1	0	0.30	0.30	0.30	na
Pikeminnow	WB-Fillet	Benz[a]anthracene	PAHs	1	0	0.049	0.049	0.049	na
Pikeminnow	WB-Fillet	Benzo[a]pyrene	PAHs	1	0	1.4	1.4	1.4	na
Pikeminnow	WB-Fillet	Benzo[e]pyrene	PAHs	1	0	1.3	1.3	1.3	na
Pikeminnow	WB-Fillet	Benzo[ghi]perylene	PAHs	1	1	0.68	0.68	0.68	na
Pikeminnow	WB-Fillet	Benzo[b/j/k]fluoranthenes	PAHs	1	0	1.3	1.3	1.3	na
Pikeminnow	WB-Fillet	Chrysene	PAHs	1	0	0.078	0.078	0.078	na
Pikeminnow	WB-Fillet	Dibenz[ah]anthracene	PAHs	1	1	0.80	0.80	0.80	na
Pikeminnow	WB-Fillet	Fluoranthene	PAHs	1	1	0.78	0.78	0.78	na
Pikeminnow	WB-Fillet	Fluorene	PAHs	1	1	2.3	2.3	2.3	na
Pikeminnow	WB-Fillet	Indeno[1,2,3-cd]pyrene	PAHs	1	1	0.55	0.55	0.55	na
Pikeminnow	WB-Fillet	Naphthalene	PAHs	1	1	5.1	5.1	5.1	na
Pikeminnow	WB-Fillet	Perylene	PAHs	1	0	2.0	2.0	2.0	na
Pikeminnow	WB-Fillet	Phenanthrene	PAHs	1	1	2.3	2.3	2.3	na
Pikeminnow	WB-Fillet	Pyrene	PAHs	1	1	0.42	0.42	0.42	na
Sucker	Fillet	2,3,7,8-TCDD	Dioxin/Furans	1	1	0.000080	0.000080	0.000080	na
Sucker	Fillet	1,2,3,7,8-PeCDD	Dioxin/Furans	1	1	0.000060	0.000060	0.000060	na
Sucker	Fillet	1,2,3,4,7,8-HxCDD	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Sucker	Fillet	1,2,3,6,7,8-HxCDD	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Sucker	Fillet	1,2,3,7,8,9-HxCDD	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Sucker	Fillet	1,2,3,4,6,7,8-HpCDD	Dioxin/Furans	1	1	0.00014	0.00014	0.00014	na
Sucker	Fillet	OCDD	Dioxin/Furans	1	1	0.00045	0.00045	0.00045	na
Sucker	Fillet	2,3,7,8-TCDF	Dioxin/Furans	1	1	0.00014	0.00014	0.00014	na
Sucker	Fillet	1,2,3,7,8-PeCDF	Dioxin/Furans	1	0	0.000050	0.000050	0.000050	na
Sucker	Fillet	2,3,4,7,8-PeCDF	Dioxin/Furans	1	0	0.000050	0.000050	0.000050	na
Sucker	Fillet	1,2,3,4,7,8-HxCDF	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Sucker	Fillet	1,2,3,6,7,8-HxCDF	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Sucker	Fillet	1,2,3,7,8,9-HxCDF	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Sucker	Fillet	2,3,4,6,7,8-HxCDF	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Sucker	Fillet	1,2,3,4,6,7,8-HpCDF	Dioxin/Furans	1	0	0.00015	0.00015	0.00015	na
Sucker	Fillet	1,2,3,4,7,8,9-HpCDF	Dioxin/Furans	1	0	0.00015	0.00015	0.00015	na
Sucker	Fillet	OCDF	Dioxin/Furans	1	0	0.00030	0.00030	0.00030	na
Sucker	Fillet	Antimony	Trace Metals	1	0	1.0	1.0	1.0	na
Sucker	Fillet	Arsenic	Trace Metals	1	1	80	80	80	na
Sucker	Fillet	Total Inorganic Arsenic	Trace Metals	1	1	4.0	4.0	4.0	na
Sucker	Fillet	Beryllium	Trace Metals	1	0	1 0	1.0	1.0	na
Sucker	Fillet	Cadmium	Trace Metals	1	0	10	10	10	na
Sucker	Fillet	Chromium	Trace Metals	1	1	140	140	140	na
Sucker	Fillet	Copper	Trace Metals	1	1	390	390	390	na
Sucker	Fillet	Lead	Trace Metals	1	0	5.0	5.0	5.0	na
Sucker	Fillet	Mercury	Trace Metals	1	1	160	160	160	na
Sucker	Fillet	Nickel	Trace Metals	1	1	20	20	20	na
Sucker	Fillet	Silver	Trace Metals	1	1	20	20	20	na
Sucker	Fillet	Thallium	Trace Metals	1	0	2.0	2.0	2.0	na

Table D-1. Summary statistics for fish species

Species	Sample Type	Chemical	Chemical Group	Number of Samples	Detection Frequency	Minimum (ug/kg)	Maximum (ug/kg)	Average (ug/kg)	Standard Deviation
Sucker	Fillet	Zinc	Trace Metals	1	1	8,300	8,300	8,300	na
Sucker	Fillet	Aroclor 1242	PCB Aroclors	1	0	30	30	30	na
Sucker	Fillet	Aroclor 1254	PCB Aroclors	1	0	63	63	63	na
Sucker	Fillet	Aroclor 1260	PCB Aroclors	1	0	46	46	46	na
Sucker	Fillet	33'44'-TeCB	PCB Congeners	1	1	0.012	0.012	0.012	na
Sucker	Fillet	233'44'-PeCB	PCB Congeners	1	1	0.36	0.36	0.36	na
Sucker	Fillet	2344'5-PeCB	PCB Congeners	1	1	0.031	0.031	0.031	na
Sucker	Fillet	23'44'5-PeCB	PCB Congeners	1	1	1.2	1.2	1.2	na
Sucker	Fillet	2'344'5-PeCB	PCB Congeners	1	1	0.045	0.045	0.045	na
Sucker	Fillet	33'44'5-PeCB	PCB Congeners	1	0	0.0029	0.0029	0.0029	na
Sucker	Fillet	233'44'5-HxCB	PCB Congeners	1	1	0.17	0.17	0.17	na
Sucker	Fillet	23'44'55'-HxCB	PCB Congeners	1	1	0.074	0.074	0.074	na
Sucker	Fillet	33'44'55'-HxCB	PCB Congeners	1	1	0.0032	0.0032	0.0032	na
Sucker	Fillet	22'33'44'5-HpCB	PCB Congeners	1	1	0.32	0.32	0.32	na
Sucker	Fillet	22'344'55'-HpCB	PCB Congeners	1	1	0.85	0.85	0.85	na
Sucker	Fillet	233'44'55'-HpCB	PCB Congeners	1	1	0.013	0.013	0.013	na
Sucker	Fillet	Aldrin	Pesticides	1	0	3.6	3.6	3.6	na
Sucker	Fillet	alpha HCH	Pesticides	1	0	6.2	6.2	6.2	na
Sucker	Fillet	alpha-Endosulfan (I)	Pesticides	1	0	0.020	0.020	0.020	na
Sucker	Fillet	beta HCH	Pesticides	1	0	8.7	8.7	8.7	na
Sucker	Fillet	cis-Chlordane	Pesticides	1	0	2.3	2.3	2.3	na
Sucker	Fillet	cis-Nonachlor	Pesticides	1	0	2.1	2.1	2.1	na
Sucker	Fillet	o,p'-DDD	Pesticides	1	0	1.2	1.2	1.2	na
Sucker	Fillet	o,p'-DDE	Pesticides	1	0	3.2	3.2	3.2	na
Sucker	Fillet	o,p'-DDT	Pesticides	1	0	2.5	2.5	2.5	na
Sucker	Fillet	p,p'-DDD	Pesticides	1	1	3.8	3.8	3.8	na
Sucker	Fillet	p,p'-DDE	Pesticides	1	1	21	21	21	na
Sucker	Fillet	p,p'-DDT	Pesticides	1	0	3.1	3.1	3.1	na
Sucker	Fillet	Dieldrin	Pesticides	1	1	0.42	0.42	0.42	na
Sucker	Fillet	Endrin	Pesticides	1	0	0.020	0.020	0.020	na
Sucker	Fillet	gamma HCH	Pesticides	1	0	5.0	5.0	5.0	na
Sucker	Fillet	Heptachlor	Pesticides	1	0	17	17	17	na
Sucker	Fillet	Heptachlor Epoxide	Pesticides	1	1	0.030	0.030	0.030	na
Sucker	Fillet	Hexachlorobenzene	Pesticides	1	0	2.0	2.0	2.0	na
Sucker	Fillet	Methoxychlor	Pesticides	1	0	0.020	0.020	0.020	na
Sucker	Fillet	Mirex	Pesticides	1	0	1.6	1.6	1.6	na
Sucker	Fillet	Oxychlordane	Pesticides	1	0	27	27	27	na
Sucker	Fillet	trans-Chlordane	Pesticides	1	0	2.7	2.7	2.7	na
Sucker	Fillet	trans-Nonachlor	Pesticides	1	0	3.0	3.0	3.0	na
Sucker	Fillet	Acenaphthene	PAHs	2	1	0.44	0.44	0.44	na
Sucker	Fillet	Acenaphthylene	PAHs	2	1	0.59	0.59	0.59	na
Sucker	Fillet	Anthracene	PAHs	2	1	2.9	2.9	2.9	na
Sucker	Fillet	Benz[a]anthracene	PAHs	2	0	0.20	0.20	0.20	na
Sucker	Fillet	Benzo[a]pyrene	PAHs	2	0	0.59	0.59	0.59	na
Sucker	Fillet	Benzo[e]pyrene	PAHs	2	0	0.40	0.40	0.40	na
Sucker	Fillet	Benzo[ghi]perylene	PAHs	2	0	0.47	0.47	0.47	na
Sucker	Fillet	Benzo[b/j/k]fluoranthenes	PAHs	2	0	0.44	0.44	0.44	na
Sucker	Fillet	Chrysene	PAHs	2	0	0.25	0.25	0.25	na
Sucker	Fillet	Dibenz[ah]anthracene	PAHs	2	0	0.85	0.85	0.85	na
Sucker	Fillet	Fluoranthene	PAHs	2	1	0.46	0.46	0.46	na
Sucker	Fillet	Fluorene	PAHs	2	1	0.57	0.57	0.57	na
Sucker	Fillet	Indeno[1,2,3-cd]pyrene	PAHs	2	0	0.28	0.54	0.41	0.18
Sucker	Fillet	Naphthalene	PAHs	2	1	5.2	5.2	5.2	na
Sucker	Fillet	Perylene	PAHs	2	0	0.87	0.87	0.87	na
Sucker	Fillet	Phenanthrene	PAHs	2	1	0.36	0.36	0.36	na
Sucker	Fillet	Pyrene	PAHs	2	1	1.9	1.9	1.9	na
Sucker	WB	2,3,7,8-TCDD	Dioxin/Furans	2	2	0.00031	0.00039	0.00035	0.000057
Sucker	WB	1,2,3,7,8-PeCDD	Dioxin/Furans	2	2	0.00028	0.00058	0.00043	0.00021
Sucker	WB	1,2,3,4,7,8-HxCDD	Dioxin/Furans	2	2	0.00011	0.00033	0.00022	0.00016
Sucker	WB	1,2,3,6,7,8-HxCDD	Dioxin/Furans	2	2	0.00034	0.00077	0.00056	0.00030
Sucker	WB	1,2,3,7,8,9-HxCDD	Dioxin/Furans	2	1	0.00022	0.00022	0.00014	0.00012
Sucker	WB	1,2,3,4,6,7,8-HpCDD	Dioxin/Furans	2	2	0.0013	0.0013	0.0013	0.0000010
Sucker	WB	OCDD	Dioxin/Furans	2	2	0.0027	0.0069	0.0048	0.0030
Sucker	WB	2,3,7,8-TCDF	Dioxin/Furans	2	2	0.00056	0.00097	0.00076	0.00029
Sucker	WB	1,2,3,7,8-PeCDF	Dioxin/Furans	2	2	0.000069	0.00018	0.00012	0.000078
Sucker	WB	2,3,4,7,8-PeCDF	Dioxin/Furans	2	2	0.00014	0.00048	0.00031	0.00024
Sucker	WB	1,2,3,4,7,8-HxCDF	Dioxin/Furans	2	1	0.00022	0.00022	0.00014	0.00012
Sucker	WB	1,2,3,6,7,8-HxCDF	Dioxin/Furans	2	1	0.00018	0.00018	0.00012	0.000092
Sucker	WB	1,2,3,7,8,9-HxCDF	Dioxin/Furans	2	1	0.00020	0.00020	0.00013	0.00011
Sucker	WB	2,3,4,6,7,8-HxCDF	Dioxin/Furans	2	1	0.00026	0.00026	0.00016	0.00015
Sucker	WB	1,2,3,4,6,7,8-HpCDF	Dioxin/Furans	2	1	0.00027	0.00027	0.00017	0.00014
Sucker	WB	1,2,3,4,7,8,9-HpCDF	Dioxin/Furans	2	1	0.00020	0.00020	0.00014	0.000088
Sucker	WB	OCDF	Dioxin/Furans	2	2	0.00039	0.00047	0.00043	0.000060
Sucker	WB	Antimony	Trace Metals	2	1	0.79	1.0	0.65	0.21
Sucker	WB	Arsenic	Trace Metals	2	2	120	130	130	9.2
Sucker	WB	Total Inorganic Arsenic	Trace Metals	2	2	16	23	19	4.8
Sucker	WB	Beryllium	Trace Metals	2	2	3.7	10	6.9	4.4
Sucker	WB	Cadmium	Trace Metals	2	2	7.9	10	9.0	1.5

Table D-1. Summary statistics for fish species

Species	Sample Type	Chemical	Chemical Group	Number of Samples	Detection Frequency	Minimum (ug/kg)	Maximum (ug/kg)	Average (ug/kg)	Standard Deviation
Sucker	WB	Chromium	Trace Metals	2	2	320	420	370	73
Sucker	WB	Copper	Trace Metals	2	2	1,800	1,800	1,800	45
Sucker	WB	Lead	Trace Metals	2	2	37	84	61	33
Sucker	WB	Mercury	Trace Metals	2	2	110	120	120	6.9
Sucker	WB	Nickel	Trace Metals	2	2	310	310	310	1.1
Sucker	WB	Silver	Trace Metals	2	1	10	38	21	23
Sucker	WB	Thallium	Trace Metals	2	0	2.0	2.0	2.0	0.00
Sucker	WB	Zinc	Trace Metals	2	2	11,000	14,000	13,000	1,700
Sucker	WB	Aroclor 1242	PCB Aroclors	1	2	6.7	18	9.3	3.6
Sucker	WB	Aroclor 1254	PCB Aroclors	1	2	53	78	59	8.3
Sucker	WB	Aroclor 1260	PCB Aroclors	1	2	36	53	40	5.4
Sucker	WB	33'44'-TeCB	PCB Congeners	2	2	0.053	0.068	0.061	0.010
Sucker	WB	233'44'-PeCB	PCB Congeners	2	2	1.6	1.7	1.7	0.057
Sucker	WB	2344'5-PeCB	PCB Congeners	2	2	0.12	0.12	0.12	0.0033
Sucker	WB	23'44'5-PeCB	PCB Congeners	2	2	5.1	5.1	5.1	0.010
Sucker	WB	2'344'5-PeCB	PCB Congeners	2	2	0.18	0.20	0.19	0.012
Sucker	WB	33'44'5-PeCB	PCB Congeners	2	2	0.010	0.016	0.013	0.0042
Sucker	WB	233'44'5-HxCB	PCB Congeners	2	2	0.72	0.79	0.75	0.051
Sucker	WB	23'44'55'-HxCB	PCB Congeners	2	2	0.31	0.33	0.32	0.016
Sucker	WB	33'44'55'-HxCB	PCB Congeners	2	2	0.00	0.020	0.016	0.0057
Sucker	WB	22'33'44'5-HpCB	PCB Congeners	2	2	1.3	1.4	1.4	0.064
Sucker	WB	22'344'55'-HpCB	PCB Congeners	2	2	3.6	3.8	3.7	0.16
Sucker	WB	233'44'55'-HpCB	PCB Congeners	2	2	0.055	0.059	0.057	0.0030
Sucker	WB	Aldrin	Pesticides	2	1	1.1	1.6	0.96	0.20
Sucker	WB	alpha HCH	Pesticides	2	2	0.83	3.4	1.5	0.90
Sucker	WB	alpha-Endosulfan (I)	Pesticides	2	0	0.010	0.033	0.022	0.016
Sucker	WB	beta HCH	Pesticides	2	1	0.27	3.9	1.1	1.2
Sucker	WB	cis-Chlordane	Pesticides	2	2	2.5	3.5	2.8	0.40
Sucker	WB	cis-Nonachlor	Pesticides	2	2	1.8	2.5	1.9	0.20
Sucker	WB	o,p'-DDD	Pesticides	2	2	1.1	2.7	1.8	0.94
Sucker	WB	o,p'-DDE	Pesticides	2	2	0.40	1.8	0.76	0.51
Sucker	WB	o,p'-DDT	Pesticides	2	2	1.7	3.1	2.1	0.62
Sucker	WB	p,p'-DDD	Pesticides	1	2	7.6	20	14	8.6
Sucker	WB	p,p'-DDE	Pesticides	1	2	66	85	76	14
Sucker	WB	p,p'-DDT	Pesticides	1	2	14	15	14	1.4
Sucker	WB	Dieldrin	Pesticides	2	2	1.8	5.0	3.4	2.2
Sucker	WB	Endrin	Pesticides	2	0	0.026	0.030	0.028	0.0029
Sucker	WB	gamma HCH	Pesticides	2	2	0.98	3.2	1.6	0.83
Sucker	WB	Heptachlor	Pesticides	2	0	0.16	7.2	3.7	5.0
Sucker	WB	Heptachlor Epoxide	Pesticides	2	2	0.18	0.38	0.28	0.14
Sucker	WB	Hexachlorobenzene	Pesticides	2	2	3.7	4.4	3.8	0.78
Sucker	WB	Methoxychlor	Pesticides	2	0	0.038	0.060	0.049	0.016
Sucker	WB	Mirex	Pesticides	2	2	0.11	0.76	0.27	0.23
Sucker	WB	Oxychlordane	Pesticides	2	2	1.3	13	4.3	4.3
Sucker	WB	trans-Chlordane	Pesticides	1	2	1.1	2.4	1.5	0.53
Sucker	WB	trans-Nonachlor	Pesticides	1	2	5.1	5.5	5.0	0.17
Sucker	WB	Acenaphthene	PAHs	2	2	0.62	9.7	5.1	6.5
Sucker	WB	Acenaphthylene	PAHs	2	2	0.60	1.3	0.95	0.50
Sucker	WB	Anthracene	PAHs	2	1	0.52	9.4	5.0	6.3
Sucker	WB	Benz[a]anthracene	PAHs	2	1	0.14	0.39	0.17	0.038
Sucker	WB	Benzo[a]pyrene	PAHs	2	1	0.14	0.94	0.31	0.23
Sucker	WB	Benzo[e]pyrene	PAHs	2	1	0.099	0.64	0.21	0.16
Sucker	WB	Benzo[ghi]perylene	PAHs	2	2	0.17	0.84	0.46	0.41
Sucker	WB	Benzo[b/j/k]fluoranthenes	PAHs	2	1	0.078	1.0	0.30	0.31
Sucker	WB	Chrysene	PAHs	2	1	0.22	0.36	0.26	0.060
Sucker	WB	Dibenz[ah]anthracene	PAHs	2	0	0.089	0.62	0.35	0.38
Sucker	WB	Fluoranthene	PAHs	2	2	0.80	1.0	0.92	0.17
Sucker	WB	Fluorene	PAHs	2	2	1.6	2.5	2.1	0.60
Sucker	WB	Indeno[1,2,3-cd]pyrene	PAHs	2	1	0.13	0.44	0.24	0.16
Sucker	WB	Naphthalene	PAHs	2	2	4.4	8.0	6.2	2.6
Sucker	WB	Perylene	PAHs	2	1	0.48	1.1	0.71	0.33
Sucker	WB	Phenanthrene	PAHs	2	1	2.6	3.9	3.2	0.89
Sucker	WB	Pyrene	PAHs	2	1	0.44	1.7	1.1	0.91
Sucker	WB-fillet	2,3,7,8-TCDD	Dioxin/Furans	1	1	0.00047	0.00047	0.00047	na
Sucker	WB-fillet	1,2,3,7,8-PeCDD	Dioxin/Furans	1	1	0.00043	0.00043	0.00043	na
Sucker	WB-fillet	1,2,3,4,7,8-HxCDD	Dioxin/Furans	1	1	0.00015	0.00015	0.00015	na
Sucker	WB-fillet	1,2,3,6,7,8-HxCDD	Dioxin/Furans	1	1	0.00055	0.00055	0.00055	na
Sucker	WB-fillet	1,2,3,7,8,9-HxCDD	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Sucker	WB-fillet	1,2,3,4,6,7,8-HpCDD	Dioxin/Furans	1	1	0.0020	0.0020	0.0020	na
Sucker	WB-fillet	OCDD	Dioxin/Furans	1	1	0.011	0.011	0.011	na
Sucker	WB-fillet	2,3,7,8-TCDF	Dioxin/Furans	1	1	0.00085	0.00085	0.00085	na
Sucker	WB-fillet	1,2,3,7,8-PeCDF	Dioxin/Furans	1	1	0.00010	0.00010	0.00010	na
Sucker	WB-fillet	2,3,4,7,8-PeCDF	Dioxin/Furans	1	1	0.00022	0.00022	0.00022	na
Sucker	WB-fillet	1,2,3,4,7,8-HxCDF	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Sucker	WB-fillet	1,2,3,6,7,8-HxCDF	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Sucker	WB-fillet	1,2,3,7,8,9-HxCDF	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Sucker	WB-fillet	2,3,4,6,7,8-HxCDF	Dioxin/Furans	1	0	0.00010	0.00010	0.00010	na
Sucker	WB-fillet	1,2,3,4,6,7,8-HpCDF	Dioxin/Furans	1	0	0.00015	0.00015	0.00015	na

Table D-1. Summary statistics for fish species

Species	Sample Type	Chemical	Chemical Group	Number of Samples	Detection Frequency	Minimum (ug/kg)	Maximum (ug/kg)	Average (ug/kg)	Standard Deviation
Sucker	WB-fillet	1,2,3,4,7,8,9-HpCDF	Dioxin/Furans	1	0	0.00015	0.00015	0.00015	na
Sucker	WB-fillet	OCDF	Dioxin/Furans	1	1	0.00055	0.00055	0.00055	na
Sucker	WB-fillet	Antimony	Trace Metals	1	1	1.0	1.0	1.0	na
Sucker	WB-fillet	Arsenic	Trace Metals	1	1	170	170	170	na
Sucker	WB-fillet	Total Inorganic Arsenic	Trace Metals	1	1	36	36	36	na
Sucker	WB-fillet	Beryllium	Trace Metals	1	1	6.0	6.0	6.0	na
Sucker	WB-fillet	Cadmium	Trace Metals	1	1	10	10	10	na
Sucker	WB-fillet	Chromium	Trace Metals	1	1	620	620	620	na
Sucker	WB-fillet	Copper	Trace Metals	1	1	2,900	2,900	2,900	na
Sucker	WB-fillet	Lead	Trace Metals	1	1	140	140	140	na
Sucker	WB-fillet	Mercury	Trace Metals	1	1	75	75	75	na
Sucker	WB-fillet	Nickel	Trace Metals	1	1	510	510	510	na
Sucker	WB-fillet	Silver	Trace Metals	1	1	50	50	50	na
Sucker	WB-fillet	Thallium	Trace Metals	1	0	2.0	2.0	2.0	na
Sucker	WB-fillet	Zinc	Trace Metals	1	1	18,000	18,000	18,000	na
Sucker	WB-fillet	Aroclor 1242	PCB Aroclors	1	1	9.6	9.6	9.6	na
Sucker	WB-fillet	Aroclor 1254	PCB Aroclors	1	1	88	88	88	na
Sucker	WB-fillet	Aroclor 1260	PCB Aroclors	1	1	58	58	58	na
Sucker	WB-fillet	33'44'-TeCB	PCB Congeners	1	1	0.082	0.082	0.082	na
Sucker	WB-fillet	233'44'-PeCB	PCB Congeners	1	1	2.5	2.5	2.5	na
Sucker	WB-fillet	2344'5-PeCB	PCB Congeners	1	1	0.19	0.19	0.19	na
Sucker	WB-fillet	23'44'5-PeCB	PCB Congeners	1	1	7.8	7.8	7.8	na
Sucker	WB-fillet	2'344'5-PeCB	PCB Congeners	1	1	0.28	0.28	0.28	na
Sucker	WB-fillet	33'44'5-PeCB	PCB Congeners	1	1	0.016	0.016	0.016	na
Sucker	WB-fillet	233'44'5-HxCB	PCB Congeners	1	1	1.1	1.1	1.1	na
Sucker	WB-fillet	23'44'55'-HxCB	PCB Congeners	1	1	0.47	0.47	0.47	na
Sucker	WB-fillet	33'44'55'-HxCB	PCB Congeners	1	1	0.018	0.018	0.018	na
Sucker	WB-fillet	22'33'44'5-HpCB	PCB Congeners	1	1	2.0	2.0	2.0	na
Sucker	WB-fillet	22'344'55'-HpCB	PCB Congeners	1	1	5.9	5.9	5.9	na
Sucker	WB-fillet	233'44'55'-HpCB	PCB Congeners	1	1	0.084	0.084	0.084	na
Sucker	WB-fillet	Aldrin	Pesticides	2	0	0.26	0.26	0.26	na
Sucker	WB-fillet	alpha HCH	Pesticides	2	1	1.4	1.4	1.4	na
Sucker	WB-fillet	alpha-Endosulfan (I)	Pesticides	2	0	0.020	0.020	0.020	na
Sucker	WB-fillet	beta HCH	Pesticides	2	0	0.58	0.58	0.58	na
Sucker	WB-fillet	cis-Chlordane	Pesticides	2	1	4.4	4.4	4.4	na
Sucker	WB-fillet	cis-Nonachlor	Pesticides	2	1	2.8	2.8	2.8	na
Sucker	WB-fillet	o,p'-DDD	Pesticides	2	1	3.7	3.7	3.7	na
Sucker	WB-fillet	o,p'-DDE	Pesticides	2	1	0.79	0.79	0.79	na
Sucker	WB-fillet	o,p'-DDT	Pesticides	2	1	3.5	3.5	3.5	na
Sucker	WB-fillet	p,p'-DDD	Pesticides	2	1	31	31	31	na
Sucker	WB-fillet	p,p'-DDE	Pesticides	2	1	130	130	130	na
Sucker	WB-fillet	p,p'-DDT	Pesticides	2	1	21	21	21	na
Sucker	WB-fillet	Dieldrin	Pesticides	2	1	2.8	2.8	2.8	na
Sucker	WB-fillet	Endrin	Pesticides	2	0	0.030	0.030	0.030	na
Sucker	WB-fillet	gamma HCH	Pesticides	2	1	1.9	1.9	1.9	na
Sucker	WB-fillet	Heptachlor	Pesticides	2	0	0.37	0.37	0.37	na
Sucker	WB-fillet	Heptachlor Epoxide	Pesticides	2	1	0.28	0.28	0.28	na
Sucker	WB-fillet	Hexachlorobenzene	Pesticides	2	1	4.9	4.9	4.9	na
Sucker	WB-fillet	Methoxychlor	Pesticides	2	0	0.050	0.050	0.050	na
Sucker	WB-fillet	Mirex	Pesticides	2	1	0.18	0.18	0.18	na
Sucker	WB-fillet	Oxychlordane	Pesticides	2	1	3.0	3.0	3.0	na
Sucker	WB-fillet	trans-Chlordane	Pesticides	2	1	2.2	2.2	2.2	na
Sucker	WB-fillet	trans-Nonachlor	Pesticides	2	1	7.2	7.2	7.2	na
Sucker	WB-Fillet	Acenaphthene	PAHs	1	1	0.75	0.75	0.75	na
Sucker	WB-Fillet	Acenaphthylene	PAHs	1	1	1.8	1.8	1.8	na
Sucker	WB-Fillet	Anthracene	PAHs	1	1	14	14	14	na
Sucker	WB-Fillet	Benz[a]anthracene	PAHs	1	0	0.52	0.52	0.52	na
Sucker	WB-Fillet	Benzo[a]pyrene	PAHs	1	0	1.2	1.2	1.2	na
Sucker	WB-Fillet	Benzo[e]pyrene	PAHs	1	0	0.81	0.81	0.81	na
Sucker	WB-Fillet	Benzo[ghi]perylene	PAHs	1	1	1.1	1.1	1.1	na
Sucker	WB-Fillet	Benzo[b/j/k]fluoranthenes	PAHs	1	0	0.85	0.85	0.85	na
Sucker	WB-Fillet	Chrysene	PAHs	1	1	0.43	0.43	0.43	na
Sucker	WB-Fillet	Dibenz[ah]anthracene	PAHs	1	0	0.47	0.47	0.47	na
Sucker	WB-Fillet	Fluoranthene	PAHs	1	1	1.5	1.5	1.5	na
Sucker	WB-Fillet	Fluorene	PAHs	1	1	2.4	2.4	2.4	na
Sucker	WB-Fillet	Indeno[1,2,3-cd]pyrene	PAHs	1	1	0.46	0.46	0.46	na
Sucker	WB-Fillet	Naphthalene	PAHs	1	1	10	10	10	na
Sucker	WB-Fillet	Perylene	PAHs	1	1	1.3	1.3	1.3	na
Sucker	WB-Fillet	Phenanthrene	PAHs	1	1	6.3	6.3	6.3	na
Sucker	WB-Fillet	Pyrene	PAHs	1	1	1.6	1.6	1.6	na

APPENDIX E

Regional Comparisons of COPC Concentrations

Table E-1. Comparison summary statistics

Analyte		Bass Fillet WFWF (current)[a]	WFWF (historical)[b]	LWR[c]	LCR[d]
TlA	Detection Frequency	1/2			
	Minimum	< 0.003			
	Maximum	0.005			
	Mean	0.0033			
	Standard Deviation	0.0025			
	Units	mg/kg			
	Collection Date	1999			
	Data Source	EVS 2000			
Hg	Detection Frequency	2/2	1/1		
	Minimum	0.33	0.1		
	Maximum	0.42	0.1		
	Mean	0.38	0.1		
	Standard Deviation	0.057	na		
	Units	mg/kg	mg/kg		
	Collection Date	1999	1988		
	Data Source	EVS 2000	ODEQ 1994		
Aldrin	Detection Frequency	0/2			0/1
	Minimum	< 0.08			< 10
	Maximum	< 0.09			< 10
	Mean	0.043			5
	Standard Deviation	0.0035			na
	Units	ug/kg			ug/kg
	Collection Date	1999			1990
	Data Source	EVS 2000			Schuler 1994
Chlordane	Detection Frequency	2/2	0/1	0/1	1/1
	Minimum	2.3	< 5	< 3	30
	Maximum	2.6	< 5	< 3	30
	Mean	2.1	2.5	1.5	30
	Standard Deviation	0.092	na	na	na
	Units	ug/kg	ug/kg	ug/kg	ug/kg
	Collection Date	1999	1988	1988	1990
	Data Source	EVS 2000	ODEQ 1994	ODEQ 1994	Schuler 1994
DDE	Detection Frequency	2/2			1/1
	Minimum	14			190
	Maximum	18			190
	Mean	16			190
	Standard Deviation	2.8			na
	Units	ug/kg			ug/kg
	Collection Date	1999			1990
	Data Source	EVS 2000			Schuler 1994
Dieldrin	Detection Frequency	2/2	0/1	1/1	1/1
	Minimum	0.23	< 5	4	10
	Maximum	0.24	< 5	4	10
	Mean	0.24	2.5	4	10
	Standard Deviation	0.007	na	na	na
	Units	ug/kg	ug/kg	ug/kg	ug/kg
	Collection Date	1999	1988	1988	1990
	Data Source	EVS 2000	ODEQ 1994	ODEQ 1994	Schuler 1994
Heptachlor Epoxide	Detection Frequency	0/2	0/1	0/1	0/1
	Minimum	< 0.007	< 5	< 3	< 10
	Maximum	< 0.01	< 5	< 3	< 10
	Mean	0.0043	2.5	1.5	5
	Standard Deviation	0.0016	na	na	na
	Units	ug/kg	ug/kg	ug/kg	ug/kg
	Collection Date	1999	1988	1988	1990
	Data Source	EVS 2000	ODEQ 1994	ODEQ 1994	Schuler 1994

Table E-1. Comparison summary statistics

Analyte		Bass Fillet			
		WFWF (current) [a]	WFWF (historical) [b]	LWR [c]	LCR [d]
1,2,3,7,8-PeCDD	Detection Frequency	2/2			
	Minimum	0.1			
	Maximum	0.11			
	Mean	0.11			
	Standard Deviation	0.0072			
	Units	ng/kg			
	Collection Date	1999			
	Data Source	EVS 2000			
2,3,7,8-TCDD	Detection Frequency	2/2			
	Minimum	0.1			
	Maximum	0.14			
	Mean	0.12			
	Standard Deviation	0.028			
	Units	ng/kg			
	Collection Date	1999			
	Data Source	EVS 2000			
TEC (WHO) [g]	Detection Frequency	2/2			
	Minimum	0.29			
	Maximum	0.32			
	Mean	0.31			
	Standard Deviation	0.022			
	Units	ng/kg			
	Collection Date	1999			
	Data Source	EVS 2000			
Aroclor 1254	Detection Frequency	2/2	0/1	0/1	
	Minimum	13	< 5	< 3	
	Maximum	15	< 5	< 3	
	Mean	14	2.5	1.5	
	Standard Deviation	1.4	na	na	
	Units	ug/kg	ug/kg	ug/kg	
	Collection Date	1999	1988	1988	
	Data Source	EVS 2000	ODEQ 1994	ODEQ 1994	
Aroclor 1260	Detection Frequency	2/2	0/1	0/1	
	Minimum	11	< 5	< 3	
	Maximum	11	< 5	< 3	
	Mean	11	2.5	1.5	
	Standard Deviation	na	na	na	
	Units	ug/kg	ug/kg	ug/kg	
	Collection Date	1999	1988	1988	
	Data Source	EVS 2000	ODEQ 1994	ODEQ 1994	
PCB 105	Detection Frequency	2/2			
	Minimum	0.42			
	Maximum	0.47			
	Mean	0.45			
	Standard Deviation	0.035			
	Units	ug/kg			
	Collection Date	1999			
	Data Source	EVS 2000			

Table E-1. Comparison summary statistics

Analyte		Bass Fillet WFWF (current) [a]	WFWF (historical) [b]	LWR [c]	LCR [d]
PCB 118	Detection Frequency	2/2			
	Minimum	1.3			
	Maximum	1.6			
	Mean	1.5			
	Standard Deviation	0.21			
	Units	ug/kg			
	Collection Date	1999			
	Data Source	EVS 2000			
PCB 126	Detection Frequency	1/2			
	Minimum	< 0.0037			
	Maximum	0.0047			
	Mean	0.0033			
	Standard Deviation	0.0009			
	Units	ug/kg			
	Collection Date	1999			
	Data Source	EVS 2000			
PCB 156/157	Detection Frequency	2/2			
	Minimum	0.21			
	Maximum	0.25			
	Mean	0.23			
	Standard Deviation	0.028			
	Units	ug/kg			
	Collection Date	1999			
	Data Source	EVS 2000			

NOTE: na - not applicable

[a] WFWF (current) – middle Willamette River reach extending downstream from Wheatland Ferry (RM 72) to Willamette Falls (RM 26.5) – study area for this risk assessment

[b] WFWF (historical) – middle Willamette River reach extending downstream from Wheatland Ferry (RM 72) to Willamette Falls (RM 26.5) – historical data

[c] LWR - lower Willamette River reach extending downstream from Willamette Falls to the river mouth (RM 0)

[d] LCR - lower Columbia River reach extending downstream from Bonneville Dam (RM 146) to the river mouth (RM 0)

[e] UWR - upper Willamette River reach extending downstream from the city of Eugene (RM 185) to Wheatland Ferry (RM 72)

[f] OCR - Other Columbia River refers to data collected in the main stem of the Columbia River upstream of Bonneville Dam (RM 146). The most upstream data grouped within this category was collected at RM 600.

[g] Toxicity equivalency concentration (TEC) is based on the sum of dioxin/furan World Health Organization (WHO) TEC values

Table E-1. Comparison summary statistics

Analyte		Carp Fillet and *Fillet w/o skin				
		WFWF (current) [a]	WFWF (historical) [b]	UWR [a]	LWR [c]	LCR [d]
TIA	Detection Frequency	0/1				1/1
	Minimum	< 0.003				0.001
	Maximum	< 0.003				0.001
	Mean	0.0015				0.001
	Standard Deviation	na				na
	Units	mg/kg				mg/kg
	Collection Date	1999				1994
	Data Source	EVS 2000				Tetra Tech 1996
Hg	Detection Frequency	1/1	9/9	3/3		1/1
	Minimum	0.25	0.02	0.12		0.145
	Maximum	0.25	0.46	0.2		0.145
	Mean	0.25	0.17	0.15		0.145
	Standard Deviation	na	0.12	0.046		na
	Units	mg/kg	mg/kg	mg/kg		mg/kg
	Collection Date	1999	1988-1989	1989-1990		1994
	Data Source	EVS 2000	ODEQ 1994	ODEQ 1994		Tetra Tech 1996
Aldrin	Detection Frequency	1/1	0/9	1/9	0/10	0/1
	Minimum	0.08	< 2	2	<2	< 0.01
	Maximum	0.08	< 3	20	<3	< 0.01
	Mean	0.08	1.2	3.2	1.2	0.005
	Standard Deviation	na	0.26	6.3	0.26	na
	Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
	Collection Date	1999	1988-1989	1989-1990	1988-1990	1994
	Data Source	EVS 2000	ODEQ 1994	ODEQ 1994	ODEQ 1994	Tetra Tech 1996
Chlordane	Detection Frequency	1/1	0/9	0/9	0/3	
	Minimum	9.4	< 3	< 25	< 25	
	Maximum	9.4	< 25	< 30	< 25	
	Mean	9.4	7.6	13	13	
	Standard Deviation	na	5.8	1.3	na	
	Units	ug/kg	ug/kg	ug/kg	ug/kg	
	Collection Date	1999	1988-1989	1989-1990	1990	
	Data Source	EVS 2000	ODEQ 1994	ODEQ 1994	ODEQ 1994	
DDE	Detection Frequency	1/1			3/3	1/1*
	Minimum	170.2			2	130
	Maximum	170.2			68	130
	Mean	170.2			41	130
	Standard Deviation	na			35	na
	Units	ug/kg			ug/kg	ug/kg
	Collection Date	1999			1990	1994
	Data Source	EVS 2000			ODEQ 1994	Tetra Tech 1996
Dieldrin	Detection Frequency	1/1	1/9	0/9	0/3	0/1
	Minimum	1.8	< 2	< 2	< 2	< 0.02
	Maximum	1.8	10	< 3	< 2	< 0.02
	Mean	1.8	2.2	1.2	1	0.01
	Standard Deviation	na	2.9	0.25	na	na
	Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
	Collection Date	1999	1988-1989	1989-1990	1990	1994
	Data Source	EVS 2000	ODEQ 1994	ODEQ 1994	ODEQ 1994	Tetra Tech 1996
Heptachlor Epoxide	Detection Frequency	1/1	2/9	0/9	0/3	0/1
	Minimum	0.17	< 2	< 2	< 2	< 0.01
	Maximum	0.17	6	< 3	< 2	< 0.01
	Mean	0.17	2.1	1.2	1	0.005
	Standard Deviation	na	1.7	0 25	na	na
	Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
	Collection Date	1999	1988-1989	1989-1990	1990	1994
	Data Source	EVS 2000	ODEQ 1994	ODEQ 1994	ODEQ 1994	Tetra Tech 1996

Table E-1. Comparison summary statistics

Analyte		Carp Fillet and *Fillet w/o skin				
		WFWF (current) [a]	WFWF (historical) [b]	UWR [e]	LWR [c]	LCR [d]
1,2,3,7,8-PeCDD	Detection Frequency	1/1				0/1
	Minimum	0.42				< 1.14
	Maximum	0.42				< 1.14
	Mean	0.42				0.57
	Standard Deviation	na				na
	Units	ng/kg				ng/kg
	Collection Date	1999				1994
	Data Source	EVS 2000				Tetra Tech 1996
2,3,7,8-TCDD	Detection Frequency	1/1		6/6*		0/1
	Minimum	0.38		0.16		< 1.14
	Maximum	0.38		0.58		< 1.14
	Mean	0.38		0.34		0.57
	Standard Deviation	na		0.18		na
	Units	ng/kg		ng/kg		ng/kg
	Collection Date	1999		1990		1994
	Data Source	EVS 2000		Curtis 1994		Tetra Tech 1996
TEC (WHO) [g]	Detection Frequency	1/1			3/3*	1/1
	Minimum	1.2			0.48	3.27
	Maximum	1.2			3.7	3.27
	Mean	1.2			1.6	3.27
	Standard Deviation	na			1.8	na
	Units	ng/kg			ng/kg	ng/kg
	Collection Date	1999			1990	1994
	Data Source	EVS 2000			Curtis 1994	Tetra Tech 1996
Aroclor 1254	Detection Frequency	1/1	2/9	0/9	0/3	0/1
	Minimum	36	< 3	< 25	< 25	< 1.11
	Maximum	36	205	< 30	< 25	< 1.11
	Mean	36	42	13	13	0.56
	Standard Deviation	na	70	1.3	na	na
	Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
	Collection Date	1999	1988-1989	1989-1990	1990	1994
	Data Source	EVS 2000	ODEQ 1994	ODEQ 1994	ODEQ 1994	Tetra Tech 1996
Aroclor 1260	Detection Frequency	1/1	3/9	0/9	2/3	1/1
	Minimum	32	< 3	< 25	< 25	140
	Maximum	32	119	< 30	1400	140
	Mean	32	29	13	480	140
	Standard Deviation	na	38	1.3	800	na
	Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
	Collection Date	1999	1988-1989	1989-1990	1990	1994
	Data Source	EVS 2000	ODEQ 1994	ODEQ 1994	ODEQ 1994	Tetra Tech 1996
PCB 105	Detection Frequency	1/1		0/6	1/3	
	Minimum	1		< 2	< 2	
	Maximum	1		< 2	6	
	Mean	1		1	2.7	
	Standard Deviation	na		na	2.9	
	Units	ug/kg		ug/kg	ug/kg	
	Collection Date	1999		1990	1990	
	Data Source	EVS 2000		ODEQ 1994	ODEQ 1994	

Table E-1. Comparison summary statistics

Analyte		Carp Fillet and *Fillet w/o skin				
		WFWF (current) [a]	WFWF (historical) [b]	UWR [e]	LWR [c]	LCR [d]
PCB 118	Detection Frequency	1/1				
	Minimum	3.8				
	Maximum	3.8				
	Mean	3.8				
	Standard Deviation	na				
	Units	ug/kg				
	Collection Date	1999				
	Data Source	EVS 2000				
PCB 126	Detection Frequency	1/1		0/6	1/3	
	Minimum	0.0089		< 2	< 2	
	Maximum	0.0089		< 2	21	
	Mean	0.0089		1	7.7	
	Standard Deviation	na		na	12	
	Units	ug/kg		ug/kg	ug/kg	
	Collection Date	1999		1990	1990	
	Data Source	EVS 2000		ODEQ 1994	ODEQ 1994	
PCB 156/157	Detection Frequency	1/1				
	Minimum	0.6				
	Maximum	0.6				
	Mean	0.6				
	Standard Deviation	na				
	Units	ug/kg				
	Collection Date	1999				
	Data Source	EVS 2000				

NOTE: na - not applicable

[a] WFWF (current) – middle Willamette River reach extending downstream from Wheatland Ferry (RM 72) to Willamette Falls (RM 26.5) – study area for this risk assessment

[b] WFWF (historical) – middle Willamette River reach extending downstream from Wheatland Ferry (RM 72) to Willamette Falls (RM 26.5) – historical data

[c] LWR - lower Willamette River reach extending downstream from Willamette Falls to the river mouth (RM 0)

[d] LCR - lower Columbia River reach extending downstream from Bonneville Dam (RM 146) to the river mouth (RM 0)

[e] UWR - upper Willamette River reach extending downstream from the city of Eugene (RM 185) to Wheatland Ferry (RM 72)

[f] OCR - Other Columbia River refers to data collected in the main stem of the Columbia River upstream of Bonneville Dam (RM 146). The most upstream data grouped within this category was collected at RM 600.

[g] Toxicity equivalency concentration (TEC) is based on the sum of dioxin/furan World Health Organization (WHO) TEC values

Table E-1. Comparison summary statistics

Analyte		Carp WB				
		WFWF (current) [a]	LCR [d]	LCR [d]	LCR [d]	LCR [d]
TIA	Detection Frequency	5/5				
	Minimum	0.003				
	Maximum	0.009				
	Mean	0.0057				
	Standard Deviation	0.0024				
	Units	mg/kg				
	Collection Date	1999				
	Data Source	EVS 2000				
Hg	Detection Frequency	5/5	8/8	1/2		
	Minimum	0.096	0.056	< 0.001		
	Maximum	0.162	1	0.15		
	Mean	0.13	0.219	0.073		
	Standard Deviation	0.029	0.32	0.1		
	Units	mg/kg	mg/kg	mg/kg		
	Collection Date	1999	1991	1993		
	Data Source	EVS 2000	Tetra Tech 1993	Tetra Tech 1994		
Aldrin	Detection Frequency	4/5	1/9	0/2		0/7
	Minimum	0.11	3	< 2.5		< 10
	Maximum	2.4	9.6	< 2.5		< 10
	Mean	1.3	2.5	1.3		5
	Standard Deviation	1.1	2.7	na		na
	Units	ug/kg	ug/kg	ug/kg		ug/kg
	Collection Date	1999	1991	1993		1990-1991
	Data Source	EVS 2000	Tetra Tech 1993	Tetra Tech 1994		Schuler 1994
Chlordane	Detection Frequency	5/5	0/9			5/7
	Minimum	18	< 3			< 10
	Maximum	26	< 3			40
	Mean	21	1.5			16
	Standard Deviation	3.5	na			13
	Units	ug/kg	ug/kg			ug/kg
	Collection Date	1999	1991			1990-1991
	Data Source	EVS 2000	Tetra Tech 1993			Schuler 1994
DDE	Detection Frequency	5/5	9/9	2/2	3/3	13/13
	Minimum	120	20	68	24	20
	Maximum	300	102	105	49	270
	Mean	190	43	84	40	108
	Standard Deviation	73	32	26	14	71
	Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
	Collection Date	1999	1991	1993	1994	1990-1991
	Data Source	EVS 2000	Tetra Tech 1993	Tetra Tech 1994	Thomas 1997	Schuler 1994
Dieldrin	Detection Frequency	6/6	2/9	0/2	3/3	0/13
	Minimum	1.9	< 3	< 5	0.72	< 10
	Maximum	5.6	10	< 5	3.9	< 20
	Mean	3.7	2.6	2.5	2.2	5.8
	Standard Deviation	1.4	1.7	na	1.6	1.9
	Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
	Collection Date	1999	1991	1993	1994	1990-1991
	Data Source	EVS 2000	Tetra Tech 1993	Tetra Tech 1994	Thomas 1997	Schuler 1994
Heptachlor Epoxide	Detection Frequency	6/6	0/9	0/2	2/3	0/13
	Minimum	0.18	< 3	< 2.5	< 0.24	< 10
	Maximum	0.44	< 4	< 2.5	0.47	< 10
	Mean	0.31	1.6	1.25	0.26	5
	Standard Deviation	0.11	0.17	na	0.2	na
	Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
	Collection Date	1999	1991	1993	1994	1990-1991
	Data Source	EVS 2000	Tetra Tech 1993	Tetra Tech 1994	Thomas 1997	Schuler 1994

Table E-1. Comparison summary statistics

Analyte		Carp WB				
		WFWF (current)[a]	LCR[d]	LCR[d]	LCR[d]	LCR[d]
1,2,3,7,8-PeCDD	Detection Frequency	5/5	5/5	0/2	1/3	2/4
	Minimum	0.8	0.84	< 0.5	< 0.3	< 1
	Maximum	1.6	1.9	< 1.1	0.3	9
	Mean	1.1	1.4	0.4	0.25	2.8
	Standard Deviation	0.35	0.46	0.2	0.05	4.2
	Units	ng/kg	ng/kg	ng/kg	ng/kg	ng/kg
	Collection Date	1999	1991	1993	1994	1990-1991
	Data Source	EVS 2000	Tetra Tech 1993	Tetra Tech 1994	Thomas 1997	Schuler 1994
2,3,7,8-TCDD	Detection Frequency	5/5	5/5	0/2	3/3	9/13
	Minimum	0.63	1.3	< 0.3	0.2	< 1
	Maximum	1.31	2.1	< 1.1	1	5
	Mean	0.82	1.6	0.35	0.7	2
	Standard Deviation	0.29	0.33	0.28	0.44	1.5
	Units	ng/kg	ng/kg	ng/kg	ng/kg	ng/kg
	Collection Date	1999	1991	1993	1994	1990-1991
	Data Source	EVS 2000	Tetra Tech 1993	Tetra Tech 1994	Thomas 1997	Schuler 1994
TEC (WHO)[g]	Detection Frequency	5/5	5/5	2/2	3/3	13/13
	Minimum	2.2	3.3	1.5	0.9	0.55
	Maximum	11	6.1	2.3	2.4	28
	Mean	4.6	5	1.9	1.5	4.9
	Standard Deviation	3.8	1.2	0.57	0.76	7.2
	Units	ng/kg	ng/kg	ng/kg	ng/kg	ng/kg
	Collection Date	1999	1991	1993	1994	1990-1991
	Data Source	EVS 2000	Tetra Tech 1993	Tetra Tech 1994	Thomas 1997	Schuler 1994
Aroclor 1254	Detection Frequency	5/5	5/9	2/2		
	Minimum	59	< 50	36		
	Maximum	110	270	65		
	Mean	75	110	51		
	Standard Deviation	21	104	21		
	Units	ug/kg	ug/kg	ug/kg		
	Collection Date	1999	1991	1993		
	Data Source	EVS 2000	Tetra Tech 1993	Tetra Tech 1994		
Aroclor 1260	Detection Frequency	5/5	4/9	1/2		
	Minimum	40	< 50	< 30		
	Maximum	120	110	52		
	Mean	65	50	28		
	Standard Deviation	32	32	2.8		
	Units	ug/kg	ug/kg	ug/kg		
	Collection Date	1999	1991	1993		
	Data Source	EVS 2000	Tetra Tech 1993	Tetra Tech 1994		
PCB 105	Detection Frequency	5/5				
	Minimum	1.6				
	Maximum	2.8				
	Mean	2				
	Standard Deviation	0.47				
	Units	ug/kg				
	Collection Date	1999				
	Data Source	EVS 2000				

Table E-1. Comparison summary statistics

Analyte		Carp WB				
		WFWF (current) [a]	LCR [d]	LCR [d]	LCR [d]	LCR [d]
PCB 118	Detection Frequency	5/5				
	Minimum	6.4				
	Maximum	11				
	Mean	7.8				
	Standard Deviation	1.8				
	Units	ug/kg				
	Collection Date	1999				
	Data Source	EVS 2000				
PCB 126	Detection Frequency	4/5				
	Minimum	< 0.014				
	Maximum	0.024				
	Mean	0.015				
	Standard Deviation	0.002				
	Units	ug/kg				
	Collection Date	1999				
	Data Source	EVS 2000				
PCB 156/157	Detection Frequency	5/5				
	Minimum	0.78				
	Maximum	1.8				
	Mean	1.1				
	Standard Deviation	0.39				
	Units	ug/kg				
	Collection Date	1999				
	Data Source	EVS 2000				

NOTE: na - not applicable

[a] WFWF (current) – middle Willamette River reach extending downstream from Wheatland Ferry (RM 72) to Willamette Falls (RM 26.5) – study area for this risk assessment

[b] WFWF (historical) – middle Willamette River reach extending downstream from Wheatland Ferry (RM 72) to Willamette Falls (RM 26.5) – historical data

[c] LWR - lower Willamette River reach extending downstream from Willamette Falls to the river mouth (RM 0)

[d] LCR - lower Columbia River reach extending downstream from Bonneville Dam (RM 146) to the river mouth (RM 0)

[e] UWR - upper Willamette River reach extending downstream from the city of Eugene (RM 185) to Wheatland Ferry (RM 72)

[f] OCR - Other Columbia River refers to *data collected in the main stem of the* Columbia River upstream of Bonneville Dam (RM 146). The most upstream data grouped within this category was collected at RM 600.

[g] Toxicity equivalency concentration (TEC) is based on the sum of dioxin/furan World Health Organization (WHO) TEC values

Table E-1. Comparison summary statistics

Analyte		Pikeminnow Fillet			
		WFWF (current) [a]	WFWF (historical) [b]	LWR [c]	LCR [d]
TIA	Detection Frequency	0/1			
	Minimum	< 0.003			
	Maximum	< 0.003			
	Mean	0.0015			
	Standard Deviation	na			
	Units	mg/kg			
	Collection Date	1999			
	Data Source	EVS 2000			
Hg	Detection Frequency	1/1	4/4	1/1	4/4
	Minimum	0.72	0.14	0.49	0.23
	Maximum	0.72	0.44	0.49	0.74
	Mean	0.72	0.29	0.49	0.42
	Standard Deviation	na	0.13	na	0.22
	Units	mg/kg	mg/kg	mg/kg	mg/kg
	Collection Date	1999	1988-1989	1989	1987
	Data Source	EVS 2000	ODEQ 1994	ODEQ 1994	USEPA 1992
Aldrin	Detection Frequency	1/1	0/4	0/3	
	Minimum	6.5	< 2	< 2	
	Maximum	6.5	< 8	< 4	
	Mean	6.5	2.1	1.5	
	Standard Deviation	na	1.3	0.5	
	Units	ug/kg	ug/kg	ug/kg	
	Collection Date	1999	1988-1989	1988-1989	
	Data Source	EVS 2000	ODEQ 1994	ODEQ 1994	
Chlordane	Detection Frequency	1/1	0/4	0/2	
	Minimum	5.5	< 2	< 25	
	Maximum	5.5	< 8	< 30	
	Mean	4.1	2.3	14	
	Standard Deviation	na	1.3	1.8	
	Units	ug/kg	ug/kg	ug/kg	
	Collection Date	1999	1988-1989	1989	
	Data Source	EVS 2000	ODEQ 1994	ODEQ 1994	
DDE	Detection Frequency	1/1			
	Minimum	22			
	Maximum	22			
	Mean	22			
	Standard Deviation	na			
	Units	ug/kg			
	Collection Date	1999			
	Data Source	EVS 2000			
Dieldrin	Detection Frequency	1/1	0/4	0/2	0/2
	Minimum	0.52	< 2	< 2	< 2.5
	Maximum	0.52	< 8	< 3	< 2.5
	Mean	0.52	2.1	1.3	1.3
	Standard Deviation	na	1.3	0.35	na
	Units	ug/kg	ug/kg	ug/kg	ug/kg
	Collection Date	1999	1988-1989	1989	1987
	Data Source	EVS 2000	ODEQ 1994	ODEQ 1994	USEPA 1992
Heptachlor Epoxide	Detection Frequency	0/1			
	Minimum	< 0.01			
	Maximum	< 0.01			
	Mean	0.005			
	Standard Deviation	na			
	Units	ug/kg			
	Collection Date	1999			
	Data Source	EVS 2000			

Table E-1. Comparison summary statistics

Analyte		Pikeminnow Fillet			
		WFWF (current) [a]	WFWF (historical) [b]	LWR [c]	LCR [d]
1,2,3,7,8-PeCDD	Detection Frequency	1/1			3/5
	Minimum	0.18			< 0.49
	Maximum	0.18			1.2
	Mean	0.18			0.68
	Standard Deviation	na			0.19
	Units	ng/kg			ng/kg
	Collection Date	1999			1987
	Data Source	EVS 2000			USEPA 1992
2,3,7,8-TCDD	Detection Frequency	1/1			5/5
	Minimum	0.13			1.1
	Maximum	0.13			1.8
	Mean	0.13			1.5
	Standard Deviation	na			0.27
	Units	ng/kg			ng/kg
	Collection Date	1999			1987
	Data Source	EVS 2000			USEPA 1992
TEC (WHO) [g]	Detection Frequency	1/1			
	Minimum	0.46			
	Maximum	0.46			
	Mean	0.46			
	Standard Deviation	na			
	Units	ng/kg			
	Collection Date	1999			
	Data Source	EVS 2000			
Aroclor 1254	Detection Frequency	1/1	0/3	0/2	
	Minimum	16	< 3	< 25	
	Maximum	16	< 25	< 30	
	Mean	16	5.3	14	
	Standard Deviation	na	6.2	1.8	
	Units	ug/kg	ug/kg	ug/kg	
	Collection Date	1999	1988-1989	1989	
	Data Source	EVS 2000	ODEQ 1994	ODEQ 1994	
Aroclor 1260	Detection Frequency	1/1	0/3	0/2	
	Minimum	17	< 3	< 25	
	Maximum	17	< 25	< 30	
	Mean	17	5.3	14	
	Standard Deviation	na	6.2	1.8	
	Units	ug/kg	ug/kg	ug/kg	
	Collection Date	1999	1988-1989	1989	
	Data Source	EVS 2000	ODEQ 1994	ODEQ 1994	
PCB 105	Detection Frequency	1/1			
	Minimum	0.75			
	Maximum	0.75			
	Mean	0.75			
	Standard Deviation	na			
	Units	ug/kg			
	Collection Date	1999			
	Data Source	EVS 2000			

Table E-1. Comparison summary statistics

Analyte		Pikeminnow Fillet WFWF (current) [a]	WFWF (historical) [b]	LWR [c]	LCR [d]
PCB 118	Detection Frequency	1/1			
	Minimum	2.5			
	Maximum	2.5			
	Mean	2.5			
	Standard Deviation	na			
	Units	ug/kg			
	Collection Date	1999			
	Data Source	EVS 2000			
PCB 126	Detection Frequency	1/1			
	Minimum	0.0067			
	Maximum	0.0067			
	Mean	0.0067			
	Standard Deviation	na			
	Units	ug/kg			
	Collection Date	1999			
	Data Source	EVS 2000			
PCB 156/157	Detection Frequency	1/1			
	Minimum	0.4			
	Maximum	0.4			
	Mean	0.4			
	Standard Deviation	na			
	Units	ug/kg			
	Collection Date	1999			
	Data Source	EVS 2000			

NOTE: na - not applicable

[a] WFWF (current) – middle Willamette River reach extending downstream from Wheatland Ferry (RM 72) to Willamette Falls (RM 26.5) – study area for this risk assessment

[b] WFWF (historical) – middle Willamette River reach extending downstream from Wheatland Ferry (RM 72) to Willamette Falls (RM 26.5) – historical data

[c] LWR - lower Willamette River reach extending downstream from Willamette Falls to the river mouth (RM 0)

[d] LCR - lower Columbia River reach extending downstream from Bonneville Dam (RM 146) to the river mouth (RM 0)

[e] UWR - upper Willamette River reach extending downstream from the city of Eugene (RM 185) to Wheatland Ferry (RM 72)

[f] OCR - Other Columbia River refers to data collected in the main stem of the Columbia River upstream of Bonneville Dam (RM 146). The most upstream data grouped within this category was collected at RM 600.

[g] Toxicity equivalency concentration (TEC) is based on the sum of dioxin/furan World Health Organization (WHO) TEC values

Table E-1. Comparison summary statistics

Analyte		Pikeminnow WB				
		WFWF (current) [a]	UWR [a]	LWR [c]	LCR [d]	OCR [f]
TIA	Detection Frequency	0/3				
	Minimum	< 0.003				
	Maximum	< 0.006				
	Mean	0.002				
	Standard Deviation	0.0009				
	Units	mg/kg				
	Collection Date	1999				
	Data Source	EVS 2000				
Hg	Detection Frequency	3/3				
	Minimum	0.057				
	Maximum	0.49				
	Mean	0.34				
	Standard Deviation	0.25				
	Units	mg/kg				
	Collection Date	1999				
	Data Source	EVS 2000				
Aldrin	Detection Frequency	1/3	1/12	0/6	0/4	
	Minimum	< 0.03	< 2	< 2	< 10	
	Maximum	4.1	4	< 6	< 10	
	Mean	1.4	1.3	1.3	5	
	Standard Deviation	2.3	0.87	0.82	na	
	Units	ug/kg	ug/kg	ug/kg	ug/kg	
	Collection Date	1999	1990	1990	1990-1991	
	Data Source	EVS 2000	ODEQ 1994	ODEQ 1994	Schuler 1994	
Chlordane	Detection Frequency	3/3		0/3	2/4	
	Minimum	6.5		< 25	< 20	
	Maximum	15		< 75	40	
	Mean	12		21	23	
	Standard Deviation	4.6		14	15	
	Units	ug/kg		ug/kg	ug/kg	
	Collection Date	1999		1990	1990-1991	
	Data Source	EVS 2000		ODEQ 1994	Schuler 1994	
DDE	Detection Frequency	3/3		3/3	4/4	
	Minimum	45		2	90	
	Maximum	120		52	380	
	Mean	87		19	220	
	Standard Deviation	38		29	120	
	Units	ug/kg		ug/kg	ug/kg	
	Collection Date	1999		1990	1990-1991	
	Data Source	EVS 2000		ODEQ 1994	Schuler 1994	
Dieldrin	Detection Frequency	3/3		0/3	0/4	
	Minimum	0.86		< 2	< 10	
	Maximum	2.1		< 6	< 20	
	Mean	1.6		1.7	7.5	
	Standard Deviation	0.67		1.2	2.9	
	Units	ug/kg		ug/kg	ug/kg	
	Collection Date	1999		1990	1990-1991	
	Data Source	EVS 2000		ODEQ 1994	Schuler 1994	
Heptachlor Epoxide	Detection Frequency	2/3		0/3	0/4	
	Minimum	< 0.03		< 2	< 10	
	Maximum	0 16		< 6	< 10	
	Mean	0.11		1.7	5	
	Standard Deviation	0.082		1.2	na	
	Units	ug/kg		ug/kg	ug/kg	
	Collection Date	1999		1990	1990-1991	
	Data Source	EVS 2000		ODEQ 1994	Schuler 1994	

Table E-1. Comparison summary statistics

Analyte		Pikeminnow WB				
		WFWF (current) [a]	UWR [b]	LWR [c]	LCR [d]	OCR [f]
1,2,3,7,8-PeCDD	Detection Frequency	3/3			3/5	
	Minimum	0.25			< 0.5	
	Maximum	0.75			3	
	Mean	0.56			1.3	
	Standard Deviation	0.27			1.2	
	Units	ng/kg			ng/kg	
	Collection Date	1999			1990-1991	
	Data Source	EVS 2000			Schuler 1994	
2,3,7,8-TCDD	Detection Frequency	3/3			4/5	
	Minimum	0.19			< 1	
	Maximum	0.47			9	
	Mean	0.37			3.9	
	Standard Deviation	0.16			3.2	
	Units	ng/kg			ng/kg	
	Collection Date	1999			1990-1991	
	Data Source	EVS 2000			Schuler 1994	
TEC (WHO) [g]	Detection Frequency	3/3		3/3	5/5	
	Minimum	0.69		2.4	2.9	
	Maximum	8.1		4.9	22	
	Mean	3.5		3.4	11	
	Standard Deviation	4		1.3	7.4	
	Units	ng/kg		ng/kg	ng/kg	
	Collection Date	1999		1990	1990-1991	
	Data Source	EVS 2000		Curtis 1994	Schuler 1994	
Aroclor 1254	Detection Frequency	3/3		0/3		
	Minimum	28		< 25		
	Maximum	66		< 25		
	Mean	51		13		
	Standard Deviation	20		na		
	Units	ug/kg		ug/kg		
	Collection Date	1999		1990		
	Data Source	EVS 2000		ODEQ 1994		
Aroclor 1260	Detection Frequency	3/3		2/3		
	Minimum	17		< 25		
	Maximum	62		209		
	Mean	47		106		
	Standard Deviation	26		99		
	Units	ug/kg		ug/kg		
	Collection Date	1999		1990		
	Data Source	EVS 2000		ODEQ 1994		
PCB 105	Detection Frequency	3/3	0/12	3/6		
	Minimum	1.2	< 2	< 2		
	Maximum	2.6	< 2	4		
	Mean	2.1	1	2		
	Standard Deviation	0.75	na	1.3		
	Units	ug/kg	ug/kg	ug/kg		
	Collection Date	1999	1990	1990		
	Data Source	EVS 2000	ODEQ 1994	ODEQ 1994		

Table E-1. Comparison summary statistics

Analyte		Pikeminnow WB				
		WFWF (current) [a]	UWR [e]	LWR [c]	LCR [d]	OCR [f]
PCB 118	Detection Frequency	3/3				
	Minimum	4.1				
	Maximum	9.7				
	Mean	7.5				
	Standard Deviation	3				
	Units	ug/kg				
	Collection Date	1999				
	Data Source	EVS 2000				
PCB 126	Detection Frequency	3/3		1/3		
	Minimum	9		< 2		
	Maximum	25		6		
	Mean	19		2.7		
	Standard Deviation	8.5		2.9		
	Units	ug/kg		ug/kg		
	Collection Date	1999		1990		
	Data Source	EVS 2000		ODEQ 1994		
PCB 156/157	Detection Frequency	3/3				
	Minimum	0.47				
	Maximum	1.6				
	Mean	1.1				
	Standard Deviation	0.59				
	Units	ug/kg				
	Collection Date	1999				
	Data Source	EVS 2000				

NOTE: na - not applicable

[a] WFWF (current) – middle Willamette River reach extending downstream from Wheatland Ferry (RM 72) to Willamette Falls (RM 26.5) – study area for this risk assessment

[b] WFWF (historical) – middle Willamette River reach extending downstream from Wheatland Ferry (RM 72) to Willamette Falls (RM 26.5) – historical data

[c] LWR - lower Willamette River reach extending downstream from Willamette Falls to the river mouth (RM 0)

[d] LCR - lower Columbia River reach extending downstream from Bonneville Dam (RM 146) to the river mouth (RM 0)

[e] UWR - upper Willamette River reach extending downstream from the city of Eugene (RM 185) to Wheatland Ferry (RM 72)

[f] OCR - Other Columbia River refers to data collected in the main stem of the Columbia River upstream of Bonneville Dam (RM 146). The most upstream data grouped within this category was collected at RM 600.

[g] Toxicity equivalency concentration (TEC) is based on the sum of dioxin/furan World Health Organization (WHO) TEC values

Table E-1. Comparison summary statistics

		Sucker Fillet			
Analyte		WFWF (current) [a]	WFWF (historical) [b]	LWR [c]	LCR [d]
TlA	Detection Frequency	1/1			8/9
	Minimum	0.004			< 0.001
	Maximum	0.004			0.038
	Mean	0.004			0.013
	Standard Deviation	na			0.012
	Units	mg/kg			mg/kg
	Collection Date	1999			1994
	Data Source	EVS 2000			Tetra Tech 1996
Hg	Detection Frequency	1/1			9/9
	Minimum	0.16			0.12
	Maximum	0.16			0.19
	Mean	0.16			0.15
	Standard Deviation	na			0.026
	Units	mg/kg			mg/kg
	Collection Date	1999			1994
	Data Source	EVS 2000			Tetra Tech 1996
Aldrin	Detection Frequency	0/1	0/1	0/2	0/9
	Minimum	< 3.6	< 2	< 2	< 0.01
	Maximum	< 3.6	< 2	< 2	< 0.02
	Mean	1.8	1	1	0.008
	Standard Deviation	na	na	na	0.0025
	Units	ug/kg	ug/kg	ug/kg	ug/kg
	Collection Date	1999	1989	1989	1994
	Data Source	EVS 2000	ODEQ 1994	ODEQ 1994	Tetra Tech 1996
Chlordane	Detection Frequency	0/1			
	Minimum	< 37			
	Maximum	< 37			
	Mean	19			
	Standard Deviation	na			
	Units	ug/kg			
	Collection Date	1999			
	Data Source	EVS 2000			
DDE	Detection Frequency	1/1			9/9
	Minimum	24			130
	Maximum	24			130
	Mean	23			130
	Standard Deviation	na			na
	Units	ng/kg			ug/kg
	Collection Date	1999			1994
	Data Source	EVS 2000			Tetra Tech 1996
Dieldrin	Detection Frequency	1/1			0/9
	Minimum	0.42			< 0.02
	Maximum	0.42			< 0.04
	Mean	0.42			0.017
	Standard Deviation	na			0.005
	Units	ug/kg			ug/kg
	Collection Date	1999			1994
	Data Source	EVS 2000			Tetra Tech 1996
Heptachlor Epoxide	Detection Frequency	1/1			0/9
	Minimum	0.03			< 0.01
	Maximum	0 03			< 0.02
	Mean	0.03			0.008
	Standard Deviation	na			0.0025
	Units	ug/kg			ug/kg
	Collection Date	1999			1994
	Data Source	EVS 2000			Tetra Tech 1996

Table E-1. Comparison summary statistics

Analyte		Sucker Fillet WFWF (current) [a]	WFWF (historical) [b]	LWR [c]	LCR [d]
1,2,3,7,8-PeCDD	Detection Frequency	1/1			0/9
	Minimum	0.06			< 0.27
	Maximum	0.06			< 1.24
	Mean	0.06			0.28
	Standard Deviation	na			0.14
	Units	ng/kg			ng/kg
	Collection Date	1999			1994
	Data Source	EVS 2000			Tetra Tech 1996
2,3,7,8-TCDD	Detection Frequency	1/1			0/9
	Minimum	0.08			< 0.14
	Maximum	0.08			< 0.77
	Mean	0.08			0.19
	Standard Deviation	na			0.12
	Units	ng/kg			ng/kg
	Collection Date	1999			1994
	Data Source	EVS 2000			Tetra Tech 1996
TEC (WHO) [g]	Detection Frequency	1/1			9/9
	Minimum	0.21			0.47
	Maximum	0.21			1.9
	Mean	0.21			0.98
	Standard Deviation	na			0.47
	Units	ng/kg			ng/kg
	Collection Date	1999			1994
	Data Source	EVS 2000			Tetra Tech 1996
Aroclor 1254	Detection Frequency	0/1			0/9
	Minimum	< 63			< 1.11
	Maximum	< 63			< 2.22
	Mean	32			0.93
	Standard Deviation	na			0.28
	Units	ug/kg			ug/kg
	Collection Date	1999			1994
	Data Source	EVS 2000			Tetra Tech 1996
Aroclor 1260	Detection Frequency	0/1			9/9
	Minimum	< 46			14
	Maximum	< 46			58
	Mean	23			37
	Standard Deviation	na			13
	Units	ug/kg			ug/kg
	Collection Date	1999			1994
	Data Source	EVS 2000			Tetra Tech 1996
PCB 105	Detection Frequency	1/1			
	Minimum	0.36			
	Maximum	0.36			
	Mean	0.36			
	Standard Deviation	na			
	Units	ug/kg			
	Collection Date	1999			
	Data Source	EVS 2000			

Table E-1. Comparison summary statistics

Analyte		Sucker Fillet WFWF (current) [a]	WFWF (historical) [b]	LWR [c]	LCR [d]
PCB 118	Detection Frequency	1/1			
	Minimum	1.2			
	Maximum	1.2			
	Mean	1.2			
	Standard Deviation	na			
	Units	ug/kg			
	Collection Date	1999			
	Data Source	EVS 2000			
PCB 126	Detection Frequency	0/1			
	Minimum	< 0.0029			
	Maximum	< 0.0029			
	Mean	0.0014			
	Standard Deviation	na			
	Units	ug/kg			
	Collection Date	1999			
	Data Source	EVS 2000			
PCB 156/157	Detection Frequency	1/1			
	Minimum	0.17			
	Maximum	0.17			
	Mean	0.17			
	Standard Deviation	na			
	Units	ug/kg			
	Collection Date	1999			
	Data Source	EVS 2000			

NOTE: na - not applicable

[a] WFWF (current) – middle Willamette River reach extending downstream from Wheatland Ferry (RM 72) to Willamette Falls (RM 26.5) – study area for this risk assessment

[b] WFWF (historical) – middle Willamette River reach extending downstream from Wheatland Ferry (RM 72) to Willamette Falls (RM 26.5) – historical data

[c] LWR - lower Willamette River reach extending downstream from Willamette Falls to the river mouth (RM 0)

[d] LCR - lower Columbia River reach extending downstream from Bonneville Dam (RM 146) to the river mouth (RM 0)

[e] UWR - upper Willamette River reach extending downstream from the city of Eugene (RM 185) to Wheatland Ferry (RM 72)

[f] OCR - Other Columbia River refers to data collected in the main stem of the Columbia River upstream of Bonneville Dam (RM 146). The most upstream data grouped within this category was collected at RM 600.

[g] Toxicity equivalency concentration (TEC) is based on the sum of dioxin/furan World Health Organization (WHO) TEC values

Table E-1. Comparison summary statistics

Analyte		Sucker WB						
		WFWF (current) [a]	LWR [c]	LCR [d]	LCR [d]	LCR [d]	LCR [d]	OCR [f]
TIA	Detection Frequency	2/2						
	Minimum	0.016						
	Maximum	0.022						
	Mean	0.019						
	Standard Deviation	0.0048						
	Units	mg/kg						
	Collection Date	1999						
	Data Source	EVS 2000						
Hg	Detection Frequency	2/2		18/18	16/16			
	Minimum	0.11		0.022	0.1			
	Maximum	0.12		0.14	0.264			
	Mean	0.12		0.08	0.168			
	Standard Deviation	0.007		0.033	0.054			
	Units	mg/kg		mg/kg	mg/kg			
	Collection Date	1999		1991	1993			
	Data Source	EVS 2000		Tetra Tech 1993	Tetra Tech 1994			
Aldrin	Detection Frequency	2/2		3/18	0/16		0/3	
	Minimum	1.1		< 3	< 2.5		< 10	
	Maximum	1.6		5.6	< 38		< 10	
	Mean	0.96		1.9	2.4		5	
	Standard Deviation	0.2		1.1	4.4		na	
	Units	ug/kg		ug/kg	ug/kg		ug/kg	
	Collection Date	1999		1991	1993		1990-1991	
	Data Source	EVS 2000		Tetra Tech 1993	Tetra Tech 1994		Schuler 1994	
Chlordane	Detection Frequency	2/2		0/18			2/4	
	Minimum	12		< 3			< 20	
	Maximum	27		< 3			30	
	Mean	16		1.5			26.7	
	Standard Deviation	5.2		na			5.77	
	Units	ug/kg		ug/kg			ug/kg	
	Collection Date	1999		1991			1990	
	Data Source	EVS 2000		Tetra Tech 1993			Schuler 1994	
DDE	Detection Frequency	2/2	1/1	9/18	16/16	2/2	21/21	
	Minimum	66	70	< 7	42.2	1.45	20	
	Maximum	87	70	103	240	105	350	
	Mean	76	70	34	107.8	53.2	91.9	
	Standard Deviation	14	na	16	40.6	73	77.9	
	Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	
	Collection Date	1999	1994	1991	1993	1994	1990	
	Data Source	EVS 2000	Thomas 1997	Tetra Tech 1993	Tetra Tech 1994	Thomas 1997	Schuler 1994	
Dieldrin	Detection Frequency	2/2	1/1	1/18	0/16	2/2	0/4	
	Minimum	1.8	27	< 3	< 5	1.96	< 10	
	Maximum	5	27	4.5	< 65	4.62	< 20	
	Mean	3.4	27	1.7	4.375	3.29	8.3	
	Standard Deviation	2.2	na	0.7	7.5	1.88	5.99	
	Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	
	Collection Date	1999	1994	1991	1993	1994	1990	
	Data Source	EVS 2000	Thomas 1997	Tetra Tech 1993	Tetra Tech 1994	Thomas 1997	Schuler 1994	
Heptachlor Epoxide	Detection Frequency	2/2	1/1	0/18	0/16	2/2	0/4	
	Minimum	0.18	2.4	< 3	< 2.5	0.34	< 10	
	Maximum	0.38	2.4	< 3	< 22	0.34	< 10	
	Mean	0.28	2.4	1.5	2.3	0.34	5.23	
	Standard Deviation	0.14	na	na	2.6	na	1.1	
	Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	
	Collection Date	1999	1994	1991	1993	1994	1990	
	Data Source	EVS 2000	Thomas 1997	Tetra Tech 1993	Tetra Tech 1994	Thomas 1997	Schuler 1994	

Table E-1. Comparison summary statistics

Analyte		Sucker WB						
		WFWF (current) [a]	LWR [c]	LCR [d]	LCR [d]	LCR [d]	LCR [d]	OCR [f]
1,2,3,7,8-PeCDD	Detection Frequency	2/2	1/1	12/12	1/16	1/2	3/5	
	Minimum	0.28	0.6	0.4	< 0.3	< 0.6	< 0.981	
	Maximum	0.58	0.6	1.1	1.4	0.6	0.995	
	Mean	0.43	0.6	0.6	0.37	0.325	0.494	
	Standard Deviation	0.21	na	0.21	0.16	0.39	0.003	
	Units	ng/kg	ng/kg	ng/kg	ng/kg	ng/kg	ng/kg	
	Collection Date	1999	1994	1991	1993	1994	1990	
	Data Source	EVS 2000	Thomas 1997	Tetra Tech 1993	Tetra Tech 1994	Thomas 1997	Schuler 1994	
2,3,7,8-TCDD	Detection Frequency	2/2	1/1	12/12	2/16	2/2	4/5	
	Minimum	0.31	0.7	0.49	< 0.1	0.4	< 0.55	
	Maximum	0.39	0.7	1.56	1.8	0.5	2.6	
	Mean	0.35	0.7	0.99	0.4	0.45	1.1	
	Standard Deviation	0.057	na	0.35	0.26	0.071	0.58	
	Units	ng/kg	ng/kg	ng/kg	ng/kg	ng/kg	ng/kg	
	Collection Date	1999	1994	1991	1993	1994	1990	
	Data Source	EVS 2000	Thomas 1997	Tetra Tech 1993	Tetra Tech 1994	Thomas 1997	Schuler 1994	
TEC (WHO) [g]	Detection Frequency	2/2	1/1	12/12	16/16	2/2	17/17	
	Minimum	1.6	2	1.7	0.98	0.75	0.55	
	Maximum	4.7	2	4.3	3.5	1.9	4.04	
	Mean	3.1	2	3	1.96	1.3	2.12	
	Standard Deviation	2.2	na	0.88	0.71	0.79	1	
	Units	ng/kg	ng/kg	ng/kg	ng/kg	ng/kg	ng/kg	
	Collection Date	1999	1994	1991	1993	1994	1990	
	Data Source	EVS 2000	Thomas 1997	Tetra Tech 1993	Tetra Tech 1994	Thomas 1997	Schuler 1994	
Aroclor 1254	Detection Frequency	2/2		17/18	16/16			
	Minimum	53		< 50	26			
	Maximum	78		380	2700			
	Mean	59		130	230			
	Standard Deviation	8.3		82	660			
	Units	ug/kg		ug/kg	ug/kg			
	Collection Date	1999		1991	1993			
	Data Source	EVS 2000		Tetra Tech 1993	Tetra Tech 1994			
Aroclor 1260	Detection Frequency	2/2		1/18	8/16			
	Minimum	36		< 50	< 27			
	Maximum	53		130	250			
	Mean	40		31	39			
	Standard Deviation	5.4		25	25.7			
	Units	ug/kg		ug/kg	ug/kg			
	Collection Date	1999		1991	1993			
	Data Source	EVS 2000		Tetra Tech 1993	Tetra Tech 1994			
PCB 105	Detection Frequency	2/2						
	Minimum	1.6						
	Maximum	1.7						
	Mean	1.7						
	Standard Deviation	0.057						
	Units	ug/kg						
	Collection Date	1999						
	Data Source	EVS 2000						

Table E-1. Comparison summary statistics

Analyte		Sucker WB						
		WFWF (current) [a]	LWR [c]	LCR [d]	LCR [d]	LCR [d]	LCR [d]	OCR [f]
PCB 118	Detection Frequency	2/2						
	Minimum	5.1						
	Maximum	5.1						
	Mean	5.1						
	Standard Deviation	0.01						
	Units	ug/kg						
	Collection Date	1999						
	Data Source	EVS 2000						
PCB 126	Detection Frequency	2/2						
	Minimum	0.01						
	Maximum	0.016						
	Mean	0.013						
	Standard Deviation	0.004						
	Units	ug/kg						
	Collection Date	1999						
	Data Source	EVS 2000						
PCB 156/157	Detection Frequency	2/2						
	Minimum	0.72						
	Maximum	0.79						
	Mean	0.75						
	Standard Deviation	0.05						
	Units	ug/kg						
	Collection Date	1999						
	Data Source	EVS 2000						

NOTE: na - not applicable

[a] WFWF (current) – middle Willamette River reach extending downstream from Wheatland Ferry (RM 72) to Willamette Falls (RM 26.5) – study area for this risk assessment

[b] WFWF (historical) – middle Willamette River reach extending downstream from Wheatland Ferry (RM 72) to Willamette Falls (RM 26.5) – historical data

[c] LWR - lower Willamette River reach extending downstream from Willamette Falls to the river mouth (RM 0)

[d] LCR - lower Columbia River reach extending downstream from Bonneville Dam (RM 146) to the river mouth (RM 0)

[e] UWR - upper Willamette River reach extending downstream from the city of Eugene (RM 185) to Wheatland Ferry (RM 72)

[f] OCR - Other Columbia River refers to data collected in the main stem of the Columbia River upstream of Bonneville Dam (RM 146). The most upstream data grouped within this category was collected at RM 600.

[g] Toxicity equivalency concentration (TEC) is based on the sum of dioxin/furan World Health Organization (WHO) TEC values